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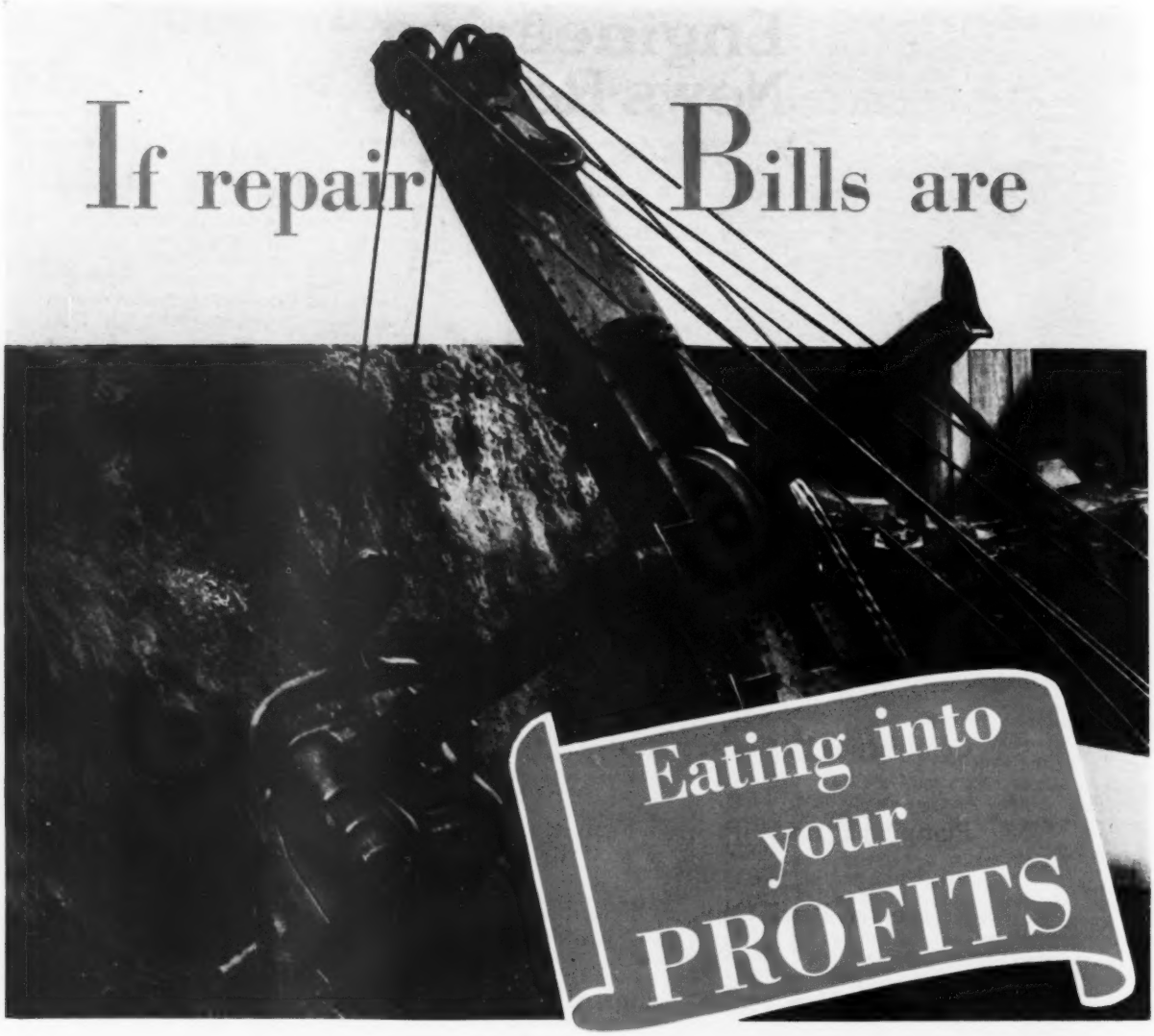

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Engineering News-Record

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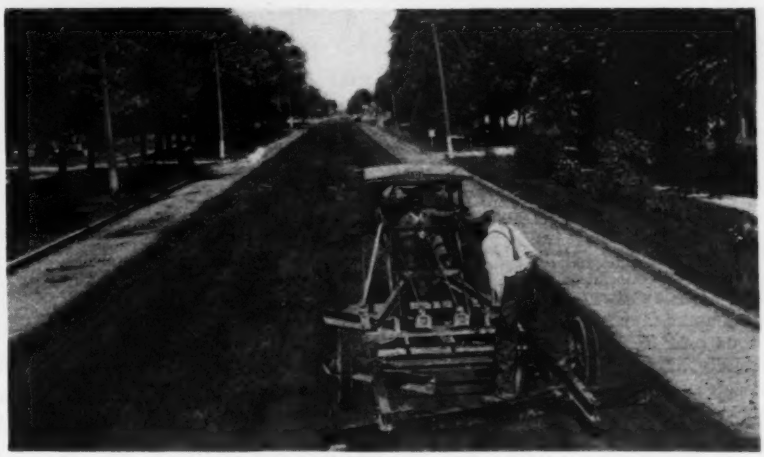
Machine-Finished Asphalt Roads in Indiana

Methods and costs of resurfacing two state roads with different types of asphalt mixes, using a self-leveling finishing machine

By A. H. Hinkle

Superintendent of Maintenance, Indiana State Highway Commission, Indianapolis, Ind.

DURING the past season a machine finisher was used on two resurfacing operations in southern Indiana, between French Lick and Louisville, under the direction of the state highway commission. The new surface was laid on an old bituminous macadam. The finishing machine was used to lay two grades of material—bituminous-coated aggregate in the first project and rock asphalt in the second project.



Planing rock asphalt with a standard maintainer pulled by a 20-hp. tractor.

Coated aggregate

The first project, 6.09 miles long, extending from the west edge of Greenville west to the Washington-Harrison County line, consisted of 3 in. of compacted rock asphalt laid on a bituminous-coated aggregate leveling course of about 1½-in. average compacted thickness. This leveling course was necessary to take out the excess crown and strengthen the old base. On this project the finisher was used only in laying the leveling course.

Previous to the resurfacing, additional superelevation was built into the old road by the use of one-man stone and waterbound macadam, surface-treated with cutback asphalt. This work was done under traffic.

The bituminous-coated aggregate used in the leveling course was made from 1½- to ¾-in. crushed limestone, coated with emulsified asphalt meeting the highway commission's specifications. The coating was done by the immersion process at the quarry site at Milltown, hauled an average of 19 miles and dumped into the finisher hopper, which spread and compacted it to the desired crown.

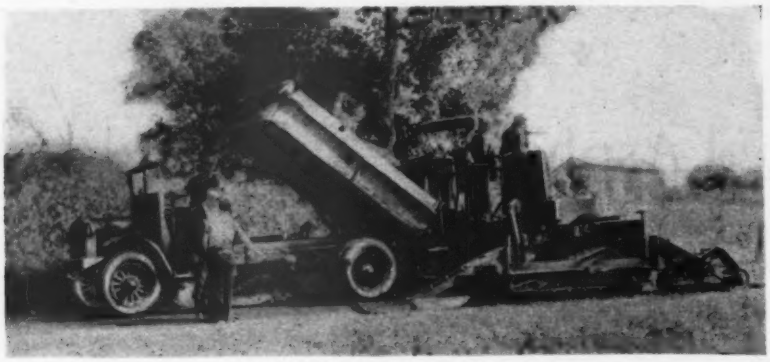
After being laid with the finisher, the coated aggregate was first rolled with a 5-ton, three-wheel roller followed with a 10-ton roller. Then ¾-in. coated aggregate was spread over the surface at the rate of about 100 cu.yd. per mile, and the surface was dragged with a maintainer that had been lengthened by using 30-ft. I-beams instead of the regular side frames. This maintainer was pulled by a 20-hp. tractor. After this planing of the ¾-in. coated aggregate, the surface was again rolled as a final operation before laying the rock-asphalt wearing course.

Incidentally, this modifying of standard makes of machinery to a longer base to produce a smooth-riding surface in cold-laid bituminous-coated aggregates demonstrates the possibilities for machinery companies in developing a new field for their equipment. These longer-base machines contribute greatly in building smoother-riding surfaces free from "bumps" ad "throws" not uncommonly experienced at high speed in bituminous surfaces laid on old roads. The use of these extremely long-base maintainers in dragging gravel and stone surfaces that are maintained by the planing process will contribute greatly to a better-riding surface on such roads. It is not necessary to use

these long-base machines, which cost more to operate, at all times. To reduce the power required to pull them, it might be well to make such long machines narrower.

The bituminous finisher started laying the 6.09 miles of coated aggregate Aug. 9 and completed it Sept. 12. The work was done in 24 working days, averaging 189 tons per day. The maximum laid in one day of ten hours was 426 tons over a lenght of about 3,000 ft. Much greater length could have been laid in a day if sufficient material had been delivered to the machine as demonstrated in the second project described later.

Asphalt spreading and finishing machine receiving mixture from truck. Device on finisher pushes truck ahead as fast as surfacing is laid.



On this bituminous-coated aggregate leveling course there was constructed a ½-in. compacted thickness of rock asphalt spread by hand. A total of 2,031.5 tons of rock asphalt, or an average of 52.2 lb. per sq.yd., was used on the total length of 6.09 miles. The rock asphalt was laid by one gang in eighteen days, averaging 113 tons per eight-hour day. The average length laid per day was 1,784 ft. The greatest amount laid in any one day was 147 tons on 2,375 ft.

After laying and carefully luting the surface, it was rolled once and then planed with a maintainer pulled by a 20-hp. wheel tractor. The surface was planed and rolled five times, and during this planing process a total of 6 lb. per sq.yd. of additional rock asphalt was fed to the surface in several applications.

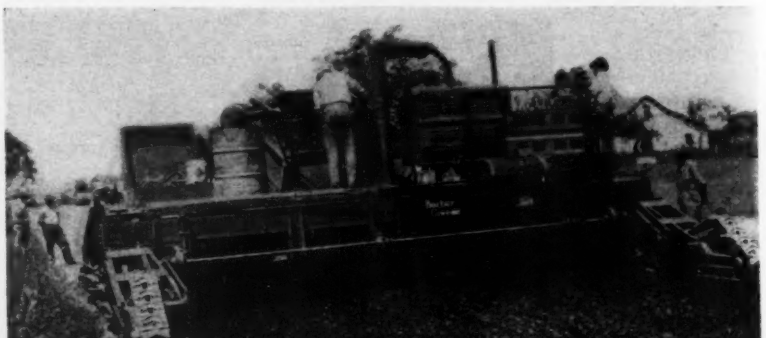
It was not deemed so necessary to use the finishing machine on the rock-asphalt wearing course of the first project, as the leveling course had been built so smooth with the finisher that it was easy to construct by hand a smooth-riding wearing course. Hence, after laying the first course the finisher was transferred to the second project.

The materials used in the first project were: for superelevation of curves, 547 cu.yd. one-man stone, 67 cu.yd. crushed stone and 8,339 gal. cutback asphalt; for the leveling course, 4,334 tons bituminous-coated aggregate; and for the wearing course, 2,132 tons rock asphalt.

The cost of the work was $7,303.64 per mile, exclusive of engineering, inspection and supervision costs. Only sufficient shoulders to hold the edge of the surface were constructed and included in the above costs.

Rock asphalt

On the second project, 19.49 miles long, extending from the Harrison-Washington County line to Paoli, the old bituminous macadam was first carefully patched with bituminous-coated aggregate. The surface was then given a treatment of about 1/20 gal. per sq.yd. of cutback asphalt, from two hours to two days before the rock asphalt was laid. The rock asphalt, of sandstone base, was shipped by rail from the plant in Kentucky and trucked from the railroad station to the work—an average haul of 9 miles. It was laid with the bituminous-finishing machine without the use of a leveling course. It was attempted to take out any remaining roughness and the excess crown in the old surface by the use of a thicker course of rock asphalt than was used in the first project, where a bituminous-coated aggregate leveling course was first laid. Due to the excess crown and variations in the old surface, the rock asphalt (which averaged about 1 in. in thickness or 97 lb. per sq.yd.) varied from as thin as ½ in. in some places in the center to a thickness as great as 3 in. at the outer edge.



Rear view of finisher laying bituminous-coated aggregate as a leveling course for the rock asphalt top.

The bituminous finisher started laying the 19.345 miles of rock asphalt on Sept. 6 and completed laying Oct. 3. The work was done in 21 working days, averaging 497 tons per day. The maximum laid in one day of 14 hours was 720 tons on a length of 1.5 miles.

The rock asphalt laid with the finisher in the second project was planed with a maintainer, which had been lengthened by welding 8-ft. extensions to the side frames, thus increasing the length of base of the maintainer in contact with the road surface from 14½ to 22½ ft. This extended maintainer was pulled by a 3-ton truck. The rock asphalt surface was rolled once before the planing started. After several planings the surface was again rolled. This process of planing and rolling was repeated several times. As the planing was done, additional rock asphalt was spread on the surface to aid in filling all depressions. This process of adding rock asphalt, planing and rolling was continued until a sufficiently smooth surface was produced. Usually three rollings, but sometimes as many as five, were required. The additional rock asphalt applied after the rolling and planing started varied from 1 to 5 lb. per sq.yd. The amount used will determine the smoothness of the surface secured up to certain limits.

This same process may be used in smoothing an old rough rock asphalt surface that may be brought back to any required degree of smoothness by continuing the alternate application of rock asphalt, planing and occasional rolling. The old rock asphalt surface should be treated with about 1/20 gal. per sq.yd. of a very light cutback asphalt, or an emulsified asphalt, before spreading the thin coat of new rock asphalt.

The old bituminous macadam surface was patched to take out so far as practicable all irregularities before the rock asphalt course was laid. The rock asphalt surface was laid to a standard width of 18 ft. Extra widening was made on curves as described later. The rock asphalt was steam-heated in cars, from which it was shoveled into hop-

pers suspended on the side of the car. From these hoppers the rock asphalt was dumped into the truck, thus eliminating any delay from waiting trucks. The rock asphalt was heated to about 160 deg. F. in the car, and when it arrived on the road it had a temperature of about 150 deg. F.

There was used in the resurfacing work on this second project 10,429 tons of rock asphalt. The cost was $6,450.52 per mile, exclusive of inspection, engineering and other supervision costs. Only sufficient shoulders were constructed to hold the edge of the newly constructed surface.

Operation of finisher

The bituminous finisher used spreads and compacts the bituminous-coated aggregate, rock asphalt or other bituminous mixture. It consists primarily of: (*a*) a hopper in front at the center of the machine to receive the material and a screw conveyor that conveys the material uniformly across the full width of the pavement being laid; (*b*) a tamper and a screed; (*c*) a frame on which is supported the tamper and screed and which contains a power unit consisting of a 48-hp. gas engine with a manually controlled governor; and (*d*) two crawler tracks and a shoe on either side which support and propel the machine.

The crawlers and shoe are connected by means of evener levers in such a manner that any unevenness in their path has a very reduced effect on the unevenness of the surface of the finished road. Ordinary care in preparing a smooth shoulder for the crawler and shoe to travel over results in a smooth-riding surface. An outstanding feature of the finisher is the means of producing a smooth surface without the use of forms. A 6-in. metal roller mounted in front of the hopper pushes against the rear wheels of the truck, thus shoving it forward as its load drops into the hopper. The crown of the finished surface is readily changed by adjustments that can be easily made.

While the finisher will travel as fast as 24 ft. per minute, it was found that to go faster than 17 ft. per minute in laying the rock asphalt was not satisfactory because the "pulling" effect of the screed upon the asphalt left the surface open and porous. When the steam-heated rock asphalt was cooler than 140 deg. F. this "pulling" effect was more noticeable. No attempt was made to lay cold rock asphalt. It is believed, however, that cold material might lay better than material heated just enough to produce a "sticky" condition that contributed to the "pulling" and produced an open surface. With the machine traveling 17 ft. per minute and including stops for normal delivery of material, it averaged better than 0.1 mile per hour.

The finisher used was built to lay a standard width of 20 ft., but by the use of baffle plates on either side a shorter width than this can be laid. The standard widths laid on the two projects were 19 ft. on the bituminous-coated aggregate and 18 ft. on the rock asphalt wearing course. Additional widths were secured on curves by two methods. An additional width of 6 in. on a side was secured by opening side doors in the baffle plates, thus allowing material to spill out over the edge, which material was leveled by hand. Greater widths than 6 in. were secured by shoveling material from in front of the tamper to the edge of the pavement as it was being laid.

Like all finishing machines the tamper is crosswise of the road. When shifting the levers to guide the machine, one side of the finisher stands still for a moment or even travels backward, while the other side goes forward. The screw conveyor that distributes the rock asphalt across the full width of the tamper operates intermittently. All this variation produces an uneven amount of tamping on the rock asphalt. The rock asphalt, being of a more or less immobile substance, was thus compacted to greater density under the places pounded most by the tamper. The slightly corrugated effect thus produced was noticeable in riding over the surface. However, through the finishing operations, consisting of planing with a long-base planer and feeding to the surface more of the loose rock asphalt, this corrugation effect was almost eliminated. It is believed, with some corrections made in the operation of the finisher and continuing the planing for a reasonable time, that these corrugations will not be apparent. Since the bituminous-coated aggregate is a more mobile material, the finisher left no trace of corrugations in it.

Liner Plates 18 Years Old Show Little Corrosion

Steel segmental liner plates, removed from old Passaic Valley sewer, Newark, N. J., show insignificant corrosion after eighteen years in earth

By J. S. Unger
Research Engineer, Commercial Shearing & Stamping Co., Youngstown, Ohio

DURING 1913 the city of Newark, N. J., together with eighteen smaller towns in the Passaic Valley, began the construction in tunnel of a 12-ft. concrete-lined sewer about 19,000 ft. long, or more than 3 miles, to serve this district. For the greater part of its length through the city of Newark the sewer was from 20 to 35 ft. under the ground level and was laid in a soil consisting of fine sand. For about 8½ per cent of the length the excavation was through a red sandstone. The inside diameter of the sewer is about 12 ft. The lining is of concrete of an average thickness of 15 in., laid against flanged steel outside liner plates of a segmental design, which were forced against the soil and bolted together in position before the inner lining of concrete was put in place. Only the top and sides for about 75 per cent of the circumference were covered. The bottom part, or approximately 25 per cent, was not covered at any portion of the sewer. The cold-flanged steel plates, of open-hearth steel, were furnished by the Hydraulic Pressed Steel Co., of Cleveland.

The work on this sewer continued for more than three years, being completed during 1915. A complete description of the work and methods of construction was published in the *Engineering Record*, Jan. 30, 1915, p. 130.

Uncovered top of sewer broken through in process of removal, showing a liner plate lifted free; holes in liner plates were burned through to permit drilling and blasting concrete lining.

In the latter part of 1932 the Pennsylvania R.R. Co. and the city of Newark removed about 500 ft. of the old sewer to accommodate the new railroad station, main-line viaduct and the city of Newark subway. This part of the sewer was replaced by a new sewer of about the same length, located outside the territory covered by the station, tracks and subway.

Condition of plates

To remove the old sewer, shafts were sunk to the top of the abandoned sewer after the sand had been dewatered by pumps and well-points driven into the sand to the lower level of the sewer. Holes were burned by gas torches

Outside view (left) and inside view (right) of one of the removed liner plates. Except for the slight distortion in removal this plate is a fair example. Note condition of nuts protected by concrete.

through the liner plates, and then holes were drilled into the concrete lining for explosive charges. The whole was torn loose by explosive, and the sewer lining plates and broken masses of concrete were removed.

Through the courtesy of William Malcolm, chief engineer for the J. Rich Steers Co., contractors for the Pennsylvania R.R. Co. on its station construction, the excavations were kept open for a considerable time to permit examination of the steel lining plates. On Oct. 18, 1932, M. E. Chamberlain, development engineer for the Carnegie Steel Co., New York, R. V. Proctor, general manager of the Commercial Shearing and Stamping Co., of Youngstown, Ohio, and the writer made an examination of the plates that were in their original position on the sewer and also of some plates that had been removed. Other visits were made a few days later by groups of engineers interested in examining the steel liner plates

These plates were 31x12x$\frac{1}{4}$ in., with a 2-in. flange turned up all around the edges. A 2x2-in. piece was cut out at each corner to permit of easy flanging and to allow for a slight bending of the flange to fit the plates together at three places in the length, as shown in the *Engineering Record* referred to previously. The outside dimensions of the plates were 35x16x$\frac{1}{4}$ in., with an estimated original weight of 19 lb. after allowing for the four corner pieces and the twelve $\frac{3}{4}$-in. holes punched in the flanges for bolting purposes.

A few plates were brushed off with a wire brush, all rust and grout that could easily be scraped was removed, and the plates were again weighed after eighteen years of service. The average weight was 19.2 lb., showing that little, if any, of the metal had been lost by rusting. The slight increase in weight is probably due to some rust and grout adhering to the plate.

The nuts on the bolts used to bolt the plates together were not rusted, but they could be moved easily by the fingers when the concrete had not covered the threads of the bolt.

After the concrete was put in place, grout was forced through a 2-in. pipe inserted in the concrete in the roof every 30 ft. This grout filled any voids between the plates and concrete, and some was forced through the joints between the plates and sometimes covered a part of the outside of the plate with a very thin coating. Wherever this grouting was found, it no doubt aided in the protection of the plates.

Tests of plates

In removing the plates some were badly distorted and bent, which caused almost all of the rusted coating on the outside surface to peel off. The inner and outer surfaces of the plates still had the original blue-black mill scale adhering to them. Very little pitting of the surfaces was noticed. The outside surface was coated with a hard, dark brown coating of rust mixed with sand, about $\frac{1}{16}$ to $\frac{1}{8}$ in. in thickness. This coating was water-resistant and almost like an enamel. An analysis of it showed the following percentages:

Ferric oxide	20.02
Silica	74.22
Alumina	1.42

It required considerable pounding to break this scale away from the plate. When broken away, the steel underneath was clean and did not show any deep pits. This indicates that rusting or corrosion took place very quickly, or within a few days or perhaps a week after the plates were in position. The absence of pitting and the presence of the adhering, thin black mill scale before it could be rusted into a brown compound verifies this belief.

A few of the old plates, slightly rusted with a yellowish-brown stain due to rusting while lying in the rain and air after removal from the sewer, were sent to Pittsburgh for chemical and physical examination. The following are the results of the chemical analyses, in percentages:

Item	Plate A	Plate B
Carbon	0.13	0.11
Manganese	0.38	0.35
Phosphorus	0.013	0.019
Sulphur	0.056	0.041
Silicon	0.008	0.008
Copper	0.04	0.05

These analyses showed the plates to be of ordinary open-hearth steel with only a trace or very small amount of copper. The tensile tests gave the following results:

Item	Plate A	Plate B
Yield point, lb. per sq.in.	58,000	58,000
Ultimate strength, lb. per sq.in.	66,500	67,000
Elongation in 2 in., per cent	33.5	20.5
Reduction of area, per cent	47.0	43.0

Cold-bending tests were made on the ends of the broken tensile tests, and all were bent 180 deg. flat, with the exception of a transverse specimen, which showed a few fine cracks at a slightly pitted part of the outside of the bend.

Taken as a whole, neither the composition nor physical tests indicated any particular properties over what is ordinarily found in the same kind of steel.

The sand lying over the sewer in contact with the liner plates was saturated with water. In order to determine if this water was mixed with some sea water, due to tide overflow, a sample of the water was collected near the exit of the dewatering pipes. This sample showed some salt to be present in the water, but the proportion of other solids found seemed to indicate that the water in the sand was contaminated by some surface water carrying brine, and not by sea water. The P_h determination of the water by the La Motte-Kenny Method showed 7.4.

Fees for Interstate Trucks on Highways Declared Legal

Collection of a fee from trucks operating over the highways of Alabama, even though engaged exclusively in interstate commerce, is within the power of the Public Service Commission of the state, according to a ruling of the state attorney-general. The attorney-general has ruled further that the commission may not withhold a permit from such truck operators but that it may hold a public hearing upon their application for a permit and may collect the same fee from them as is collected from trucks operating in intra-state traffic.

In Kentucky a restraining order has been issued against the state tax commission and the state highway commission to prevent their enforcing a recent act of the legislature restricting the tonnage of trucks and imposing other regulations upon them.

Construction by Contract Analyzed by U. S. Census

First complete analysis of contract construction offers a wealth of information on organization of business, its volume and value, the materials consumed and the labor employed—Complete figures for 30,000 and estimated figures for 144,396 contractors

AN EVENT of outstanding importance to the contracting business was the publication in 1932 of the figures of the first census of contract construction in the United States. Undertaking the work at the solicitation of leading associations of contractors, the Bureau of the Census has compiled a separate report for each state and a summary report for the United States. By means of the vast array of figures so presented the contracting business can appraise for the first time the character, volume and value of its activities and break them down in both state and nation-wide terms of organization, materials, labor, equipment and character and spread of operations. The possible number of analyses extends far beyond those undertaken in this article, which is summarized from the advance proof sheets of the report for the United States and covers the broad essential features of the business.

Plan and scope of report

The year selected for census accounting was 1929, which, coming between the peak construction-volume years of 1928-9 and the first depression year of 1930, might reasonably be presumed to be a typical and average year of the intensive building era following the business slump of 1921-'22. Decision was also made to record any construction performed by contract. It is to be noted at the outset, therefore, that the following figures do not include all construction and that work done by force account by governmental agencies and with their own construction forces for themselves by public service agencies is not included. The count does include, however, repairs and remodeling as well as new work. Also the term "contractor" is used to include any person or establishment handling construction for others whether under contract or not.

The compilation of a list of contractors under the definitions assumed was an extensive task. A gross list of 225,000 names was compiled from all sources. Checking, rechecking and elimination reduced this number to 144,396 actively engaged in construction in 1929. Through questionnaires by mail and direct canvass by the census enumerators, reports were obtained from this full number. Of these reports 30,597 were from contractors who handled a business exceeding $25,000 during the year, and 113,799 were from contractors having a smaller business. Complete records were sought from only the contractors doing a business of more than $25,000. The results were as follows:

Information	Number
Class of ownership	28,381
Location of business	29,799
Salaried members and employees	29,699
Value of equipment	26,718
Workmen employed	27,102
Distribution of expenditures	26,671
Cost of materials	21,980

A mental note of these figures is important in appraising the coverage included in the several classes of statistics which are hereafter considered.

Organization of contracting

Three types of organization are shown by the 30,597 reporting, as follows:

Type	Per cent of total
Individual ownership	44.4
Partnership	19.2
Incorporated company	36.4

The preponderance of individual proprietors in the contracting business is noticeable; also it is noticeable that where individuals have associated themselves together in the contracting business they have largely sought the legal advantages of incorporation. The age of contracting businesses was found to be as follows:

Time of Incorporating or Starting Business	All Reporting Establishments	Incorporated Establishments
Number reporting	29,623	10,554
Prior to 1900	2,814	272
Prior to 1925	19,688	5,703
Five years ending with 1929	6,628	4,659

Of 29,623 contractors only about 9½ per cent have been 30 years in business, and only about three-fourths have been in business more than five years. This was in 1929 before the real mortality due to depression had begun. From the full tabulations it is noted that of the contractors still in business in 1929 the annual accessions averaged 524 up to 1914, 827 from 1914 to 1919, and 1,589

TABLE I — PRINCIPAL AND OTHER EXPENDITURES BY GROUPS OF ESTABLISHMENTS

Item	Estimated Total for All Establishments		Establishments Reporting Expenditures							
			All Classes		Operative Builders		General Contractors		Subcontractors	
	Amount[1]	Per Cent of Total Expenditures	Amount	Per Cent of Total Expenditures	Amount	Per Cent of Total Expenditures	Amount	Per Cent of Total Expenditures	Amount	Per Cent of Total Expenditures
Number of establishments reporting	30,597	.....	26,671	.....	594	.....	12,556	.....	13,521	.....
Value of construction business	$6,250,266,665	.....	$5,549,822,607	.....	$130,802,297	.....	$3,703,514,888	.....	$1,715,505,422	.....
Total expenditures, value	5,845,175,404	100.0	5,233,254,060	100.0	128,431,951	100.0	3,501,047,552	100.0	1,603,774,557	100.0
Per cent of construction business	93.5	.....	94.3	.....	98.2	.....	94.5	.....	93.5	.....
Principal items of expenditure	$4,978,631,383	85.2	$4,457,426,987	85.2	$117,874,775	91.8	$3,014,717,572	86.1	$1,324,834,640	82.6
Subcontract work let	1,455,494,000	24.9	1,312,113,000	25.1	88,924,000	69.2	1,164,167,000	33.2	59,022,000	3.7
Wages paid	1,467,541,901	25.1	1,310,634,188	25.0	10,864,349	8.5	803,886,336	23.0	495,883,503	30.9
Cost of materials	2,055,595,482	35.2	1,834,679,799	35.1	18,086,426	14.1	1,046,664,236	29.9	769,929,137	48.0
Other items of expenditure	866,544,021	14.8	775,827,073	14.8	10,557,176	8.2	486,329,980	13.9	278,939,917	17.4
Total salaries	348,600,743	6.0	312,106,353	6.0	3,695,960	2.9	184,965,337	5.3	123,445,056	7.7
Proprietors and firm members	35,933,857	.6	32,172,006	.6	343,369	.3	13,481,435	.4	18,347,202	1.1
Salaried employees	312,666,886	5.3	279,934,347	5.3	3,352,591	2.6	171,483,902	4.9	105,097,854	6.6
Rent for equipment	25,380,060	.4	22,723,065	.4	22,253	[2]	17,951,998	.5	4,748,814	.3
Rent for offices, warehouses, etc	26,992,692	.5	24,166,879	.5	286,234	.2	11,406,949	.3	12,473,696	.8
Interest	30,962,278	.5	27,720,890	.5	2,945,157	2.3	18,297,878	.5	6,477,855	.4
Contract bond premiums	20,674,435	.4	18,510,065	.4	51,311	[2]	16,811,075	.5	1,647,679	.1
Compensation and liability insurance premiums	54,023,037	.9	48,367,462	.9	445,787	.3	33,759,264	1.0	14,162,411	.9
All other overhead (including depreciation on equipment)	359,910,776	6.2	322,232,359	6.2	3,110,474	2.4	203,137,479	5.8	115,984,406	7.2

[1] A considerable number of establishments failed to report a complete distribution of their minor expenditures, but the three principal items were reported by all establishments. The figures for the other items in this column have been estimated upon the assumption that the relative distribution for minor items was the same as for the combined total for the three major items.

[2] Less than one-tenth of 1 per cent.

TABLE II — COST OF MATERIALS IN DETAIL

Item	Cost of Materials Reported by				
	All Classes of Establishments			General Contractors[2]	Sub-contractors
	Amount	Per Cent Distribution	Per $1,000 Construction Work Done[1]		
Number of establishments reporting	30,597			15,516	15,081
Value of construction business handled	$6,250,266,665			$4,370,890,529	$1,879,376,136
Value of subcontract work let	1,455,494,000			1,394,020,000	61,474,000
Value of work done by own force	4,794,772,665			2,976,870,529	1,817,902,136
Total cost of all materials	2,055,595,482		$428.72	1,211,289,427	844,306,055
All materials distributed by kind	1,572,964,879	100.0		873,637,174	699,327,705
Sand, gravel, crushed stone, slag, cinders	164,323,947	10.4	44.79	150,007,079	14,316,868
Brick (face, common, fire, paving, etc.)	65,058,116	4.1	17.73	52,039,724	13,018,392
Cut stone, granite and marble	43,809,635	2.8	11.94	21,713,696	22,095,939
Cement	140,683,536	8.9	38.34	127,994,366	12,689,170
Plaster, etc.	14,969,326	1.0	4.08	6,206,863	8,762,463
Structural steel	128,053,585	8.1	34.90	64,872,790	63,180,795
Reinforcing steel	47,126,319	3.0	12.84	43,071,287	4,055,032
Metal doors, windows, and trim	17,508,830	1.1	4.77	6,324,596	11,184,234
Lumber, rough and finished	116,750,865	7.4	31.82	107,049,006	9,701,859
Millwork	47,008,170	3.0	12.81	43,892,678	3,115,492
Hardware, rough and finished	18,112,097	1.2	4.93	16,703,871	1,408,220
Paints, varnishes, glass	33,614,058	2.1	9.16	6,994,135	26,619,923
Roofing and sheet metal	56,035,925	3.6	15.27	6,933,787	49,102,138
Heating and ventilating equipment and supplies	125,122,220	8.0	34.10	10,636,162	114,486,058
Plumbing and gas-fitting equipment and supplies	130,987,637	8.3	35.70	10,796,385	120,191,252
Electrical appliances and supplies	99,455,264	6.3	27.11	16,035,909	83,419,355
Elevators, dumb waiters, and equipment	51,552,310	3.3	14.05	1,798,368	49,753,942
Pipe: drain tile, vitrified, concrete, segment-tile, corrugated	20,344,184	1.3	5.54	18,900,010	1,444,174
Pipe: cast-iron, sheet and tube steel, etc.	33,214,729	2.1	9.05	25,099,118	8,115,611
Bituminous paving materials, tar, asphalt, and oil	25,202,335	1.6	6.87	23,609,185	1,593,150
Machinery	18,766,994	1.2	5.11	18,410,061	356,933
Metal products, n. e. s., (including metal furniture)	19,451,852	1.2	5.30	4,110,867	15,340,985
All other materials	155,812,945	9.9	42.47	90,437,231	65,375,714

[1] The value of construction work done is obtained from figures presented in Table I, by subtracting the value of subcontract work let from the total value of construction business.
[2] Includes operative builders.

from 1920 to 1924; after 1924 there was a declining trend to 894 in 1929. Of 28,660 contractors reporting, 93.7 per cent had no branch offices. As indicating the fraternal and cooperative attitude of contractors, the tabulations show that of 30,068 reporting 13,898 were members of contractors' associations, 5½ per cent of national associations, 23.8 per cent of local and 16.9 per cent of both.

Volume of construction

The reports of total business transacted gave the following figures:

Item	All Business	Business Above $25,000
Number reporting	144,396	30,597
General contracts	$5,778,453,565	$4,911,765,910
Subcontracts	1,507,266,679	1,338,500,755
All business	$7,285,720,244	$6,250,266,665

From the gross totals the value of subcontracts is subtracted as being duplicated in the value of general contracts, leaving the values of the work actually accomplished for owners as follows:

All business	$5,578,453,565
Business above $25,000	4,794,772,665

For precise appraisal of volume and costs only the figures reported by the contractors doing a business in excess of $25,000 are considered. For this group of contractors the general balance sheet for 1929 is given by Table I. These figures epitomize the contracting business. Many analyses are possible, but an item of general interest is the relative cost of labor and materials. The combined cost of labor and materials was divided in the following ratios: wages 41.7 per cent, and materials 58.3 per cent.

Materials cost 2½ billons

The total cost of materials used by 144,396 contractors was as follows:

Businesses exceeding $25,000 a year	$2,055,595,482
Business under $25,000 a year	421,998,106
Total	$2,477,593,588

Of the total, 83 per cent was consumed by the larger contractors. Considering these contractors, the itemized figures are given in Table II. Broadly, the figures show the preponderance of concrete and steel and of materials for health and efficiency, as plumbing, heating, lighting and elevators. These figures for all construction show, of course, false ratios for individual types of construction. To bring out relative ratios more clearly, Table III is given for building construction and Table IV for highway construction. It will be noted again from these tables how lumber, steel, concrete and equipment predominate in building work, and aggregates, cements and bitumens in road work.

Wages and hours of labor

In view of unemployment conditions the figures on construction labor possess exceptional interest. Table V shows the number of workers employed according to season, and Table VI gives the working hours and earnings. A general summary is as follows:

Item	Number	Per Man
Average employed	828,772	
Value work done	$4,794,772,665	$5,785
Wages paid	1,467,541,901	1,771
Value of equipment	449,118,718	542
Cost of materials	2,055,595,482	2,480

For all establishments that had a business of more than $25,000 during the year and of the estimated total number of workmen employed throughout the year (828,772), operative builders employed less than 8 per cent, general contractors 68 per cent and subcontractors 31 per cent.

The value of construction work done, wages and materials per workman employed are less for general contractors than the average for all classes of establishments coupled with an inventory value of equipment that is higher than the average. Subcontractors, on the other hand, show the reverse relationship, with a comparatively higher relative value shown for work, wages and materials and a lower value for equipment.

The average value of construction work done per workman employed for all classes of larger establishments throughout the United States was $5,785; for operative builders, $6,792; for general contractors, $5,178; and for subcontractors, $7,096. In no sense do these figures indicate the comparative efficiency of labor employed by the respective groups. They do indicate, however, that the work of general contractors consisted of an average of more moderately priced labor, utilizing materials of moderate costs, whereas the work of subcontractors represented the installation on more highly fabricated and higher-priced materials by generally more highly skilled and highly paid labor.

During recent years a consistent effort has been made by progressive contractors in many sections of the country to minimize seasonal unemployment in

TABLE III—COST OF MATERIALS IN DETAIL FOR ESTABLISHMENTS ENGAGED PRIMARILY IN BUILDING

Item	All Classes of Building[1]			Commercial Building Only			Residential Building Only		
	Amount	Per Cent Distribution	Per $1,000 Construction Work Done by Own Force	Amount	Per Cent Distribution	Per $1,000 Construction Work Done by Own Force	Amount	Per Cent Distribution	Per $1,000 Construction Work Done by Own Force
Number of establishments reporting	10,131			539			2,455		
Value of construction business handled	$2,622,046,898			$132,627,030			$245,650,776		
Value of subcontract work let	1,124,702,000			67,126,000			105,974,000		
Value of work done by own force	1,497,344,898			65,501,030			139,676,776		
Total cost of materials	652,166,912		$435.55	25,283,592		$386.00	64,865,354		$464.40
All materials distributed by kind	438,496,051	100.0		17,320,729	100.0		43,566,501	100.0	
Sand, gravel, crushed stone, slag, cinders	37,524,832	8.6	37.27	1,847,765	10.7	41.18	1,670,506	3.8	17.81
Brick (face, common, fire, paving, etc.)	43,413,897	9.9	43.12	1,775,166	10.2	39.56	2,850,517	6.5	30.39
Tile (fireproofing)	7,061,355	1.6	7.01	208,698	1.2	4.65	240,968	.6	2.57
Tile, facing, terra cotta, floor and wall	7,509,787	1.7	7.46	406,291	2.3	9.06	719,508	1.7	7.67
Concrete and cinder block	6,289,229	1.4	6.25	268,322	1.5	5.98	753,485	1.7	8.03
Cut stone, granite and marble	15,791,997	3.6	15.68	490,571	2.8	10.93	566,265	1.3	6.04
Cement	41,997,862	9.6	41.72	2,188,461	12.6	48.77	1,557,787	3.6	16.61
Lime	3,489,365	.8	3.47	141,067	.8	3.14	340,388	.8	3.63
Plaster, etc	5,753,200	1.3	5.71	176,504	1.0	3.93	754,704	1.7	8.04
Structural steel	27,894,384	6.4	27.71	710,336	4.1	15.83	489,348	1.1	5.22
Reinforcing steel	19,331,069	4.4	19.20	1,244,899	7.2	27.74	261,274	.6	2.79
Cast iron, miscellaneous, excluding pipe	2,318,630	.5	2.30	51,842	.3	1.15	59,466	.1	.63
Metal doors, windows and trim	5,941,737	1.4	5.90	189,543	1.1	4.22	284,057	.7	3.03
Metal and wire lath and furring	2,128,739	.5	2.11	62,595	.4	1.39	160,864	.4	1.71
Ornamental metal work	2,988,852	.7	2.97	102,367	.6	2.28	170,865	.4	1.82
Lumber, rough and finished	81,760,677	18.6	81.21	3,440,606	19.9	76.68	16,053,033	36.8	171.12
Lathe, shingles, and shakes (wood)	2,667,968	.6	2.65	81,176	.5	1.81	762,218	1.7	8.13
Millwork	41,132,380	9.4	40.85	990,634	5.7	22.08	7,461,496	17.1	79.54
Composition board	3,464,924	.8	3.44	51,975	.3	1.16	468,325	1.1	4.99
Waterproofing materials	1,137,430	.3	1.13	56,260	.3	1.25	88,638	.2	.94
Hardware, rough and finished	12,966,913	3.0	12.88	568,497	3.3	12.67	1,788,089	4.1	19.06
Paints, varnishes, glass	5,967,368	1.4	5.93	212,712	1.2	4.74	908,130	2.1	9.68
Roofing and sheet metal	6,207,265	1.4	6.17	289,902	1.7	6.46	833,321	1.9	8.88
Finished flooring (other than cement, wood or tile)	3,181,171	.7	3.16	63,187	.4	1.41	489,962	1.1	5.22
Screens, shades, awnings, etc	916,575	.2	.91	19,506	.1	.44	296,482	.7	3.16
Heating and ventilating equipment and supplies	7,396,108	1.7	735	212,415	1.2	4.73	846,676	1.9	9.02
Plumbing and gas-fitting equipment and supplies	8,137,088	1.9	8.08	261,942	1.5	5.84	1,463,199	3.4	15.60
Electrical appliances and supplies	4,992,289	1.1	4.96	179,605	1.0	4.00	625,391	1.4	6.66
Elevators, dumb-waiters, and equipment	1,617,721	.4	1.61	262,906	1.5	5.86	21,810	.1	.23
Pipe: drain tile, vitrified, concrete, segment-tile, corrugated	968,104	.2	.96	18,539	.1	.41	77,871	.2	.83
Pipe: cast-iron, sheet and tube steel, etc	6,619,167	1.5	6.58	55,443	.3	1.24	28,357	.1	.30
Ready-mixed concrete	1,169,071	.3	1.16	193,045	1.1	4.30	4,655	[2]	.05
Machinery	7,390,935	1.7	7.34	320,435	1.8	7.14			
Metal products, n.e.s. (including metal furniture)	2,299,784	.5	2.28	34,481	.2	.77	9,631	[2]	.10
All other materials	9,068,178	2.1	9.01	143,036	.8	3.18	459,215	1.1	4.89

[1] Excludes operative materials. [2] Less than one-tenth of 1 per cent.

the construction industry. The seasonal trend of unemployment in the construction industry as reported by establishments that had a business of more than $25,000 during 1929 is shown by the figures in Table V. The estimated total for all establishments indicates a maximum employment of approximately 1,031,604 men about the middle of August, with only 579,396, or 56 per cent of the maximum, employed in January. August was also the month of greatest employment by general contractors, and January was the month of least employment. For subcontractors,

TABLE IV—COST OF MATERIALS IN DETAIL FOR ESTABLISHMENTS ENGAGED PRIMARILY IN HIGHWAY, STREET PAVING, AND BRIDGE AND CULVERT CONSTRUCTION

Item	Highway			Street Paving			Bridge and Culvert		
	Amount	Per Cent Distribution	Per $1,000 Construction Work Done by Own Force	Amount	Per Cent Distribution	Per $1,000 Construction Work Done by Own Force	Amount	Per Cent Distribution	Per $1,000 Construction Work Done by Own Force
Number of establishments reporting	1,514			984			475		
Value of construction business handled	$443,064,426			$282,759,559			$137,206,366		
Value of subcontract work let	43,789,000			25,230,000			11,893,000		
Value of work done by own force	399,275,426			257,529,559			125,313,366		
Total cost of all materials	165,340,861		$414.10	109,106,244		$423.66	55,658,045		$444.15
All materials distributed by kind	134,792,440	100.0		89,139,074	100.0		45,649,962	100.0	
Sand, gravel, crushed stone, slag, cinders	56,597,963	42.0	173.88	32,799,332	36.8	155.89	5,163,358	11.3	50.24
Brick (face, common, fire, paving, etc.)	1,997,417	1.5	6.14	2,631,805	3.0	12.51	272,278	.6	2.65
Concrete and cinder block	1,311,225	1.0	4.03	720,422	.8	3.42	209,987	.5	2.04
Cut stone, granite and marble	1,057,036	.8	3.25	2,491,517	2.8	11.84	630,891	1.4	6.14
Riprap, rubble, etc	409,223	.3	1.26	537,396	.6	2.55	443,930	1.0	4.32
Cement	39,856,158	29.6	122.45	26,253,224	29.5	124.78	5,486,333	12.0	53.38
Structural steel	1,725,506	1.3	5.30	353,920	.4	1.68	18,799,532	41.2	182.91
Reinforcing steel	8,458,282	6.3	25.98	2,525,348	2.8	12.00	4,708,190	10.3	45.81
Cast iron, miscellaneous, excluding pipe	159,946	.1	.49	360,231	.4	1.71	69,035	.2	.67
Lumber, rough and finished	2,582,602	1.9	7.93	1,014,997	1.1	4.83	4,043,673	8.9	39.34
Hardware, rough and finished	556,345	.4	1.71	212,622	.2	1.01	460,020	1.0	4.48
Paints, varnishes, glass	56,026	[1]	.17	25,695	[1]	.12	246,480	.5	2.40
Pipe: drain tile, vitrified, concrete, segment-tile, corrugated	2,780,076	2.1	8.54	2,101,600	2.4	9.99	154,752	.4	1.80
Pipe: cast-iron, sheet and tube steel, etc	1,258,317	.9	3.87	977,317	1.1	4.64	204,143	.4	1.99
Wire cable, guards and fencing	600,176	.4	1.84	53,688	.1	.25	290,759	.6	2.83
Bituminous paving materials, tar, asphalt and oil	10,590,221	7.9	32.54	11,576,139	13.0	55.02	227,536	.5	2.21
Wood piling and timber	79,859	.1	.24	13,378	[1]	.06	773,281	1.7	7.52
Ready-mixed concrete	345,648	.3	1.06	591,891	.7	2.81	36,100	.1	.35
All other materials	4,370,414	3.2	13.43	3,898,552	4.4	18.53	3,399,684	7.4	33.08

[1] Less than one-tenth of 1 per cent.

TABLE V — WAGE EARNERS EMPLOYED EACH MONTH BY PRINCIPAL GROUPS OF ESTABLISHMENTS

Item	Estimated Total for All Establishments		Establishments Reporting Wage Earners							
			All Classes		Operative Builders		General Contractors		Subcontractors	
	Number	Per Cent of Maximum	Number	Per Cent of Maximum	Number	Per Cent of Maximum	Number	Per Cent of Maximum	Number	Per Cent of Maximum
Number of establishments reporting	30,597	.....	27,102	.....	458	.....	13,036	.....	13,608	.....
Number of wage earners[1]										
January	579,396	56.2	530,887	56.2	4,526	53.2	329,811	48.9	196,550	74.6
February	579,834	56.2	531,289	56.2	4,768	56.0	331,196	49.2	195,325	74.2
March	647,905	62.8	593,661	62.8	6,049	71.0	377,318	56.0	210,294	79.9
April	766,991	74.3	702,776	74.3	7,450	87.5	465,386	69.0	229,940	87.3
May	862,632	83.6	790,410	83.6	8,019	94.2	541,905	80.4	240,486	91.3
June	935,427	90.7	857,110	90.7	8,401	98.7	598,414	88.8	250,295	95.0
July	997,531	96.7	914,015	96.7	8,514	100.0	647,063	96.0	258,438	98.1
August	1,031,604	100.0	945,235	100.0	8,456	99.3	674,149	100.0	262,630	99.7
September	1,006,267	97.5	922,019	97.5	7,826	91.9	650,863	96.5	263,330	100.0
October	968,734	93.9	887,629	93.9	6,725	79.0	623,088	92.4	257,816	97.9
November	861,115	83.5	789,020	83.5	5,913	69.5	544,796	80.8	238,311	90.5
December	707,821	68.6	648,560	68.6	4,943	58.1	430,299	63.8	213,318	81.0

[1]Number on payroll on 15th of each month or nearest normal working day. The estimated number of wage earners shown in the first column is based upon the ratio of wages paid by establishments reporting employment to wages paid by all establishments.

however, the months of maximum and minimum activity were September and February, respectively. Operative builders on the other hand employed most men in July and the fewest in January. As shown by the percentages of maximum employment for the respective months, the work of general contractors was more seasonal than that of subcontractors, whose activity continued more regularly throughout the year.

Length of working periods

A considerable variety in the length of working day and week in the construction industry is shown by the summary of reports of 27,102 establishments presented in Table VI.

The average wages shown at the end of this table for the respective groups by number of working days per week and number of hours per day clearly illustrate the point that men working the longer hours and the longer week earned smaller average annual wages.

These figures also show that the 5½-day week prevailed among reporting establishments of the construction industry during 1929. The greater frequency of the 5½-day week among subcontractors, coupled with a fair representation among general contractors, accounted for this average. Although the greater number of general contractors also reported the 5½-day week in force, more than half the men employed by the general contractors worked the 6-day week. More than 90 per cent of the workmen employed by subcontractors worked an 8-hour day, while only about 4 per cent worked 10 hours. Among the workmen employed by the general contractors, on the other hand, 62 per cent worked an 8-hour day and 26 per cent a 10-hour day.

Of 26,547 contractors reporting, 97.8 per cent reported no losses from strikes and lockouts. A total of 79,239 accidents to workmen was reported by 25,422 contractors, or three for each. The fatalities reported by 27,265 contractors totaled 2,406.

Equipment worth half a billion

The inventory value of equipment reported by 26,718 contractors, pro-rated to 30,597 contractors, was as follows:

	Operative Builders (750)	General Contractors (14,766)	Subcontractors (15,081)
Number..			
Value of work...	$50,381,886	$2,926,488,643	$1,817,902,136
Wages...	13,145,859	914,112,368	540,283,674
Value of equip.	690,173	360,031,291	88,397,254

About 80 per cent of the value ($449,118,718) of all construction equipment was owned by general contractors, nearly 20 per cent by subcontractors, and only 0.2 per cent by operative builders. The investment in equipment amounted to 9.4 per cent of the value of the work done, or 12.3 per cent for general contractors, 4.9 per cent for subcontractors and 1.4 for operating builders.

Class and location of work

Of the general contract business of all classes of establishments, about two-

TABLE VI — LENGTH OF WORKING WEEK, NUMBER OF WORKMEN AFFECTED AND AVERAGE ANNUAL WAGES PAID BY REPORTING ESTABLISHMENTS

Length of Working Week	All Classes of Establishments				General Contractors[1]				Subcontractors			
	Establishments Reporting	Estimate of Workmen Affected		Estimated Average Annual Wage Per Workman	Establishments Reporting	Estimate of Workmen Affected		Estimated Average Annual Wage Per Workman	Establishments Reporting	Estimate of Workmen Affected		Estimated Average Annual Wage Per Workman
		Number[2]	Per Cent of Total			Number[2]	Per Cent of Total			Number[2]	Per Cent of Total	
Total	27,102	759,384	100.0	$1,771	13,394	524,656	100.0	$1,621	13,608	234,728	100.0	$2,105
40-hour 5-day week	5,116	130,648	17.2	2,359	1,673	58,554	11.2	2,176	3,443	72,094	30.7	2,508
45-hour 5-day week	56	1,041	.2	1,740	28	653	.1	1,383	28	388	.2	2,340
50-hour 5-day week	36	894	.1	1,272	25	729	.1	1,265	11	165	.1	1,303
All other 5-day week	107	1,747	.2	2,049	34	588	.1	1,725	73	1,159	.5	2,213
44-hour 5½-day week	11,562	243,566	32.1	1,866	4,789	136,760	26.0	1,756	6,773	106,806	45.5	2,053
49½-hour 5½-day week	380	7,865	1.0	1,507	222	5,626	1.1	1,500	158	2,239	1.0	1,525
55-hour 5½-day week	528	1,054	2.6	1,135	423	18,052	3.5	1,102	105	2,002	.8	1,435
All other 5½-day week	1,475	35,733	4.7	1,544	841	25,092	4.8	1,477	634	10,641	4.5	1,703
48-hour 6-day week	3,034	100,941	13.3	1,606	1,890	87,046	16.6	1,587	1,144	13,895	5.9	1,728
54-hour 6-day week	1,419	55,097	7.2	1,637	1,022	46,500	8.9	1,617	397	8,597	3.6	1,744
60-hour 6-day week	1,886	107,065	14.1	1,309	1,630	100,580	19.2	1,312	256	6,485	2.8	1,264
All other 6-day week	811	25,680	3.4	1,479	489	20,145	3.8	1,421	322	5,535	2.4	1,691
All other not designated	342	15,719	2.1	1,554	234	12,912	2.4	1,474	108	2,807	1.2	1,923
Not reported	350	13,334	1.8	1,934	194	11,419	2.2	1,909	156	1,915	.8	2,085
Length of week reported	26,410	730,331	100.0	.....	13,066	500,325	100.0	.....	13,344	230,006	100.0	.....
5-day week	5,315	134,330	18.4	2,343	1,760	60,524	12.1	2,152	3,555	73,806	32.1	2,500
5½-day week	13,945	307,218	42.1	1,788	6,275	185,530	37.1	1,647	7,670	121,688	52.9	2,002
6-day week	7,150	288,783	39.5	1,491	5,031	254,271	50.8	1,471	2,119	34,512	15.0	1,639
Length of day reported...	24,047	667,171	100.0	4,861	11,702	454,500	100.0	4,673	12,315	212,671	100.0	5,225
8-hour day	19,712	475,155	71.2	1,957	8,352	282,360	62.1	1,791	11,360	192,795	90.7	2,200
9-hour day	1,855	64,003	9.6	1,622	1,272	52,779	11.6	1,602	583	11,224	5.3	1,721
10-hour day	2,480	128,013	19.2	1,282	2,078	119,361	26.3	1,280	372	8,652	4.1	1,304

[1]Includes operative builders. [2]Obtained by dividing by 12 the sum of the reported number of workmen on the 15th day of each month or nearest normal working day

thirds was building, 15 per cent highway and street work, and 13 per cent public works and utilities construction, leaving only about 9 per cent for the other listed classes of construction. General contractors handled 85 per cent of all building work, while subcontractors reported 15 per cent of such work directly for owners. The kinds of work that were done by subcontractors directly for the owner were, in the majority of cases, repairs or remodeling, and a small part of the work reported by general contractors was also of this nature.

More than 90 per cent of each other kind of construction business listed was handled by general contractors except the small miscellaneous items, which were about evenly divided. Almost 84 per cent of the business done directly for the owners by subcontractors was building work, and less than 8 per cent public works and utilities construction.

Building construction done under general contract or directly for the owners, valued at more than $3,500,000,000, was reported by all classes of establishments of the larger business groups throughout the United States. Of this total, commercial and residential building each represented a little less than than 28 per cent, manufacturing building 13 per cent, and educational building 10 per cent. No other designated type of building represented as much as 5 per cent of all building business.

Public works and utilities construction business handled under general contracts or directly for owners by all classes of establishments was valued at $664,095,537. About one-quarter of this amount was the value of bridge, tunnel and similar work reported by all classes of establishments. Central-station light and power-plant work represented another quarter of the total, and city sewage disposal, drainage and water supply combined a third quarter. The distribution reported by general contractors was approximately the same as that for all classes of establishments, but almost 90 per cent of the relatively small amount of public works and utilities work reported by subcontractors was done on three classes—bridge, tunnel, etc., central light and power plant and water supply.

The distribution of the $1,338,500,755 valuation of all business done under subcontract by all classes of establishments shows that 27 per cent of all such work consisted of heating and plumbing, including the related lines of pipe covering, automatic temperature control and automatic sprinkler systems. Other kinds of work, which represented a considerable proportion of the total value, were electrical (9.2 per cent), roofing and sheet-metal work (8.2 per cent), marble and tiling (7.5 per cent), steel erection (6.1 per cent) and plastering (5.9 per cent).

As reported by the 29,799 establishments throughout the United States that had a business of more than $25,000 during 1929, the total value of business of which the location was reported was $6,013,000,000. Of this amount, that reported by all classes of establishments as done in the home city was valued at $3,436,000,000, or 57.1 per cent of the total; in the home state, including the home city, at $4,956,000,000, or 82.4 per cent of the total; and outside the home state, at $1,057,000,000, or 17.6 per cent.

General contractors reported 51.8 per cent of their total business as done in the home city, 80.3 per cent in the home state, and 19.7 per cent outside the home state. Subcontractors did a greater percentage of their business in the narrower field, 67.9 per cent in the home city, 85.8 per cent in the home state, and only 14.2 per cent outside.

Pumping Plant With 3,153-Ft. Lift at Grand Canyon

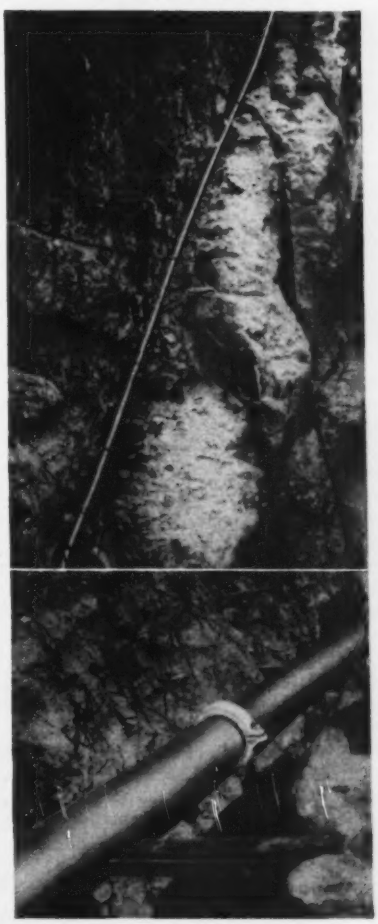
Santa Fe Railway installs high-head plant of two 34-stage units handling 170 g.p.m. to eliminate hauling water supply 98 miles by tank car for hotels and railroad use

TO ELIMINATE hauling water by tank car to supply its two hotels, station, power house and other railroad facilities on the south rim of the Grand Canyon in northern Arizona, the Atchison, Topeka & Santa Fe Railway Co. has installed a pumping plant to lift water 3,153 ft. from Indian Gardens Springs in the canyon. Water requirements average about 70,000 gal. per day, and this was hauled in tank cars from other points in the state, usually from Flagstaff, 98 miles distant. Excessive cost of this water-supply system led to the decision to provide the pumped supply. In addition to the unusual pumping equipment required for the installation, the principal engineering interest centers in the building of the 12,000-ft. pipe line that extends up the canyon wall of an average 45 per cent grade with one vertical cliff of 280 ft.

As seen from the canyon rim, the Indian Gardens area constitutes a small green patch that appears to be on the canyon floor, although actually on a natural bench 1,200 ft. above the river. On this area, extending about half a mile along the canyon and covered with trees and brush, there are two well-defined springs. To collect the gravity flow from these springs, a 70,000-gal. reinforced-concrete reservoir was constructed, 38 ft. in diameter and 10 ft. deep, divided into two compartments with drains for cleaning. To insure the collection of water below the main spring, a small dam was built at the lower end of the wooded area 200 ft. lower in elevation and 2,000 ft. below the main concrete reservoir. At this dam two vertical turbine pumps were installed with a 6-in. cast-iron pipe line delivering this supplemental supply back to the main reservoir.

The main pump house is located near the reservoir, providing a positive head for the pumps. The installation consists of four vertical, centrifugal turbine-type pumps, each unit having seventeen stages at 100 ft. per stage. Each pump is direct-connected to a 60-hp., 3,600-r.p.m., 2,300-volt motor. The pumps are suspended from I-beam supports and are connected in pairs, giving

Fig. 1—The 6-in. seamless steel pumping line was left exposed on the rock cliffs but buried elsewhere when possible. Forged steel couplings and rubber gaskets were used to join the special upset ends of the 30-ft. sections (bottom photo).



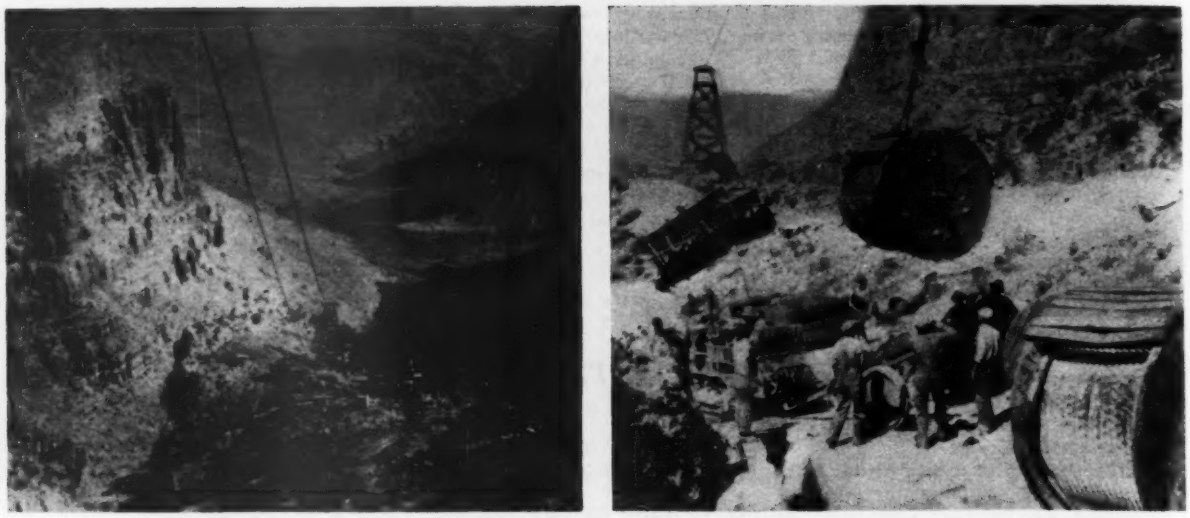


Fig. 2—A series of four cableways (600 to 2,500-ft. span) solved the serious transportation problem (left) and provided means of taking down electric cable reels, pipe and men (right).

the equivalent of two 34-stage pumps. Each of these double units is designed to handle 85 g.p.m. against a head of 3,400 ft.

The pumping equipment is provided with remote control from the power house on the rim and is designed to operate without any attendant and with only weekly inspection. In the switchboard a coded impulse-control panel is incorporated which is operated from a sending panel in the power house on the rim. By means of this remote-control system, various operations are performed, including stopping and starting the pumps, opening and closing valves and other operating requirements.

A 2-in. hydraulically operated and electrically controlled gate valve is provided on the discharge side of each pump, and the header connecting the two pumping units discharges through a 3-in. needle check valve with a motor-operated adjustment for regulating the flow to a definite quantity. In addition, there is a 2-in. automatic surge suppressor with a relief line to the reservoir and a motor-operated drain valve for emptying the pipe line if necessary. All of this valve equipment is controlled from the power house through the coded impulse systems operating over a two-wire underground cable. Thermostatically controlled electric heating is provided to prevent freezing of the small control pipes in the winter. The pumps at the collecting dam are automatically controlled by float switches in the reservoir.

Pipe-Line Construction—The pipe line consists of 6-in. seamless steel tubing with special upset ends; couplings are of forged steel and rubber gaskets fastened with two bolts. Pipe for the upper section of the line has standard wall thickness of 0.28 in. and was designed for maximum pressure of 1,000 lb. per sq.in. with 60,000-lb. ultimate strength steel. The lower section of the line has the same external diameter pipe, but the internal diameter was decreased to provide a thicker wall section of 0.3125 in. This part of the line is under a maximum working pressure of 1,470 lb., and the pipe has a 95,000-lb. ultimate strength steel.

Lengths of pipe average 30 ft., and all bends were made cold in the field with screw jacks. The pipe is galvanized both inside and out, and in the buried sections it is given additional protection with various rust-proof coatings and is wrapped.

Transportation problems presented the principal construction difficulties. When the work was started only a narrow trail was available down the cliff, and the first construction operations consisted of building a series of cableways down the proposed line. Four cableways were provided to cover the line with spans varying from 600 to 2,500 ft. Track cables were 1½ in. in diameter, traction cables ¾ in. and the load line ⅝ in. Electric driving equipment was used at the upper installation, but the three lower cableways were equipped with power engine drives. With this transportation system the material was transferred three times to land it at the lower plateau and was then transferred to trailers hauled by crawler tractor for the more gradual last half of the route to Indian Gardens. Cableways were used for transportation of men, and they effected considerable saving in time.

The location provides a gradual rise of about 10 per cent grade for the first half of the 12,000-ft. line from the pump house. At this point the line reaches the cliff forming the canyon wall, and the average grade increases to about 45 per cent with one vertical cliff 280 ft. high and several smaller ones.

About 8 per cent of the pipe line is in exposed locations where the solid rock cliffs made trenching impossible. Steel anchors are provided to secure the pipe against the rock cliff. At special locations a half-round steel protection, made by splitting 13½-in. steel casing longitudinally, was fastened over the pipe line with U-bolts to protect it and the electric cable from injuries caused by falling rocks.

Although winter temperatures may reach 20 deg. below zero along the cliff section, no insulation is provided, and the exposed pipe line is only painted to match the color of the rocks. However, an electric thermostat has been provided at the coldest section near the canyon rim to give a warning signal so that water flow can be maintained or, if necessary, the line can be drained.

A requirement of the National Park Service provided that no overhead wires be used, making it necessary to install electric cable for the permanent power supply. On the plateau section lead-covered cable is used with two outer layers of steel tape and saturated jute; on the cliff section the lead covering and steel tape are omitted and galvanized armor wire covered with jute is used. In sections where the pipe is in trench the power and control cables were laid in the trench, and on the cliff sections the cables are fastened to the pipe with galvanized clamps.

The pumped supply reaching the storage tanks at the rim is treated to a zeolite softener and chlorinated.

Engineers and contractors

Design and construction of the pumping plant was in charge of G. L. Davenport, Jr., assistant engineer, and J. M. Terrass, assistant engineer in charge of field construction, under the general supervision of M. C. Blanchard, chief engineer of the coast lines of the Atchison, Topeka & Santa Fe Railway Co. The pumps were built by the Byron Jackson Co., and the electric control equipment was constructed by the Westinghouse Electric and Mfg. Co.

Reinforced Brick Columns Tested at Lehigh University

Results of first series of tests show strength varying from 2,500 to 4,500 lb. per sq.in., reveal importance of vertical reinforcement, superiority of cement mortar and solid over-perforated brick, and advisability of using lateral ties

By Inge Lyse

Research Assistant Professor of Engineering Materials, Lehigh University, Bethlehem, Pa.

FIFTEEN brick columns recently tested at the Fritz Engineering Laboratory at Lehigh University, and comprising a pilot series for a more extensive investigation of the use of reinforced-brick masonry for columns, furnish some interesting and significant data. The columns were 12½ in. square by 10 ft. high. Three had no reinforcement, five had vertical reinforcement only, and seven had both vertical and lateral reinforcement. The bricks, of the new de-aired type, had an excellent physical appearance, showing no laminations or irregularities. Both solid bricks and perforated bricks were used. The average compressive strength of the solid brick was 13,760 lb. per sq.in. flat, 10,680 lb. per sq.in. on edge, and 10,070 lb. per sq.in. on end. Corresponding values for the perforated brick were 7,520, 5,080 and 4,840 on the gross area. The tests were carried out under the sponsorship of Judson Vogdes, representative of the National Brick Manufacturers Research Foundation and consultant to the Lehigh Brick Works, which, through Robert K. Mosser, supplied all materials and built the test columns.

The program of tests and the results obtained are given in the accompanying table. Attention is called to the fact that for columns in which 1:3 cement mortar was used the maximum strength was in no case less than 700,000 lb., or 4,500 lb. per sq.in., regardless of the amount of reinforcement or type of brick. The columns that had 1:1:6 cement-lime mortar gave considerably less strength, varying from as low as 410,500 lb. to as high as 671,000 lb., or from stresses of about 2,600 to about 4,300 lb. per sq.in. One of the columns had strength in excess of the capacity of the 800,000-lb. testing machine, so that a special loading rig, which provided for the doubling of the capacity of the machine, was constructed and used.

While the results were intended only for assisting in the design of further investigations, they indicated certain relationships that may be pointed out at this time. The longitudinal reinforcement increased the strength of the columns but did not seem to contribute its full yield-point strength of 137,000 lb. This was particularly true for columns having no lateral ties. The workmanship of the mason affected the strength of the column to a marked degree. A variation in strength of as much as 100,000 lb. may be attributed to the workmanship. The age of the columns did not seem to have any effect on the strength of the columns using cement mortar, but increased the strength of columns using cement-lime mortar. In general, the strength of the columns with cement mortar was about 200,000 lb. in excess of the strength of the columns in which cement-lime mortar was used. The columns utilizing perforated bricks gave lower strength than those having solid bricks. With cement-lime mortar the difference between the strengths of perforated and solid brick columns was about 150,000 lb. With cement mortar the difference was considerably less.

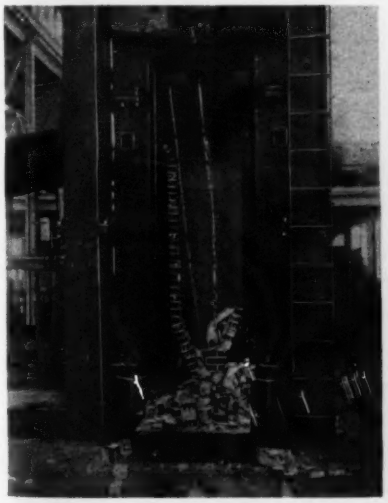
While the lateral ties did not seem to have a marked effect upon the strength of the columns, the type of failure was materially affected, as shown in the accompanying illustration. Before the maximum load was reached on any of the columns tested, cracking sounds were heard, and inspection revealed that vertical cracks had appeared. These cracks followed the vertical joints and fractured the brick along the line of cracking. The reinforced-brick columns showed a much greater toughness before failure occurred than did the plain columns. The latter collapsed completely under load. This series of tests would seem to indicate that reinforced-brick columns may be so constructed that they give very high strength and ample warning of impending failure.

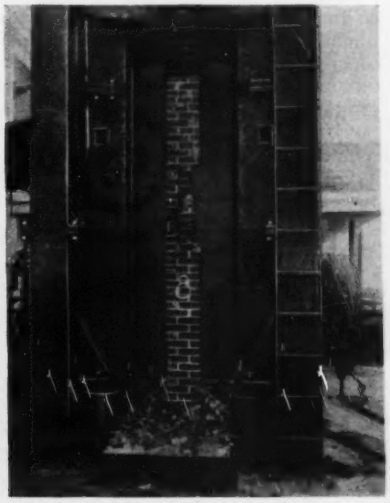
RESULTS OF BRICK COLUMN TESTS
(Columns 12½ in. square by 10 ft. high)

Mortar		Reinforcement, Vertical Per Cent	Reinforcement, Lateral Per Cent	Age, Days	Max. Load, Lb.	Type of Brick
1:3	cement	0	0	7	738,000	Solid
1:3	cement	0	0	28	800,000†	Solid
1:1:6	lime	0	0	28	410,500	Perf.
1:3	cement	2.0	0	7	800,000†	Solid
1:3	cement	2.0	0	28	810,000†	Solid
1:3	cement	2.0	0	28	708,700	Perf.
1:1:6	lime	2.0	0	28	628,200	Solid
1:1:6	lime	2.0	0	28	473,500	Perf.
1:3	cement	2.0	Ties*	7	800,000†	Solid
1:3	cement	2.0	Ties*	28	752,000	Solid
1:3	cement	2.0	Ties*	28	732,500	Perf.
1:1:6	lime	2.0	Ties*	7	483,400	Solid
1:1:6	lime	2.0	Ties*	7	584,200	Solid
1:1:6	lime	2.0	Ties*	28	671,000	Solid
1:1:6	lime	2.0	Ties*	28	527,700	Perf.

* ¼-in.-diameter lateral ties in every third joint.
† Failed under repeated loading.

Comparison of failures of reinforced-brick columns with and without lateral ties. The use of ties did not increase the strength, but it did obviate complete collapse, as shown at the left.





Street Lighting Improved in Indiana Town

The city of Garrett, Ind., with a population of 4,700, is increasing its street-lighting system, with the work being done by unemployed of the city. The ornamental lighting system, which includes about 50 five-light cluster units, is being replaced by modern fixtures. There are to be 25 twin-light and 59 single-light standards in the ornamental system. Light centers will be 18 ft. high in the case of the twin-light units and 14½ ft. for the single-light units. Within the twin standards will be 20-amp., 10,000-lumen lamps; and within the single standards will be 6.6-amp., 4,000-lumen lamps. The five-light cluster standards being replaced will be changed to single-light standards for installation in residential districts.

Expansion and Moving Fill Damage Bridge Concrete

Fifteen-year old Hanover St. bridge in Baltimore requires numerous repairs to concrete at expansion joints and in column footings

ACCUMULATING damages to the concrete parts of the Hanover St. bridge in Baltimore, Md., required the city department of public works in 1931 to undertake extensive repairs to prevent serious damage to the structure. The bridge attracted notice at the time of its construction (1914-17) as one of a few having steel cantilever spans incased in concrete to give them the semblance of concrete arches. As described in *Engineering News*, March 29, 1917, p. 497, the construction developed trouble at one of the piers and at some of the approach footings, attributed to fill pressures, but the concrete work offered no trouble and presented every indication of satisfactory quality. It has, however, in fifteen years sustained injuries in detail that called for widespread repairs.

Investigation was made (1) to determine the location and character of the injuries and the probable causes and (2) to devise methods of repair which would prevent recurrence of injury. The task was assigned to the J. E. Greiner Co., consulting engineers, this firm having been consulting engineers for the design of the original bridge, the construction of which was supervised by the state roads commission of Maryland. The consultants' report was submitted June 30, 1931, and urged immediate repairs estimated to cost $70,000, not including pavement, track and deck-slab repairs, which were separately estimated to cost about $50,000. The contract for the bridge repairs was let in October, 1931, to Victor A. Pyles Co., Inc., Baltimore, Md., and cost $65,200. The replacement of the roadway expansion joints and the necessary repairs of the roadway paving were done in 1932 by the forces of the bureau of highways.

Fig. 1—Bridge across the Patapsco River at Hanover St., Baltimore, Md., which has recently undergone repairs to concrete parts damaged by expansion and moving fill.

Bridge structure

An accompanying view, Fig. 1, shows the bridge as it appeared when repairs were begun. Briefly, it consisted, from north to south, of a wall-retained fill for about 250 ft., then an arcade approach for about 450 ft., then an end pier and six 103-ft. cantilever spans, then a bascule of 150-ft. clear span, and then six more cantilever spans, an end pier and a short approach. The total length of the bridge is 2,290 ft., made up of the north approach, 1,522 ft. of bridge proper and 68 ft. of south approach.

The piers and abutments, arcade column footings and walls were founded on timber piles. The walls and arcade columns and arches were of reinforced concrete. Each main bridge span, except the bascule, consisted of ten steel cantilever ribs, incased in concrete, carrying reinforced-concrete spandrel columns and arches supporting a reinforced-concrete roadway deck. The piers for the cantilever spans were of unusual design, as shown by the accompanying drawing, Fig. 2, consisting of a cap carried by a buttressed wall on a wide footing embracing the pile tops, all of reinforced concrete. The piers for the bascule were in pairs connected by transverse curtain walls. The retaining walls and arcade column footings for the north approach call for notice only to mention that both were tied together across the bridge by reinforcing bars inclosed in concrete. These pier, wall and footing members are of significance in connection with certain happenings during construction and afterwards, as disclosed in the examination to determine the plan of repairs.

At the time of construction water covered all the area occupied by the north approach structures. This original stream width is indicated by the general view of the bridge, Fig. 1. The bottom, considering the entire across-river profile, was mud 70 ft. or more deep, then a hard gravel and sand stratum, and then another layer of mud about 10 ft. deep over hard material. The foundation piles therefore ranged from 65 to 85 ft. in length, and in the north approach some were 100 ft. long. To construct this approach, a fill was planned under the approach structures to above water level and out to the first main bridge pier. The designers planned to make this fill and give it time to settle before the piles for the approach foundation were driven with land drivers. But its completion before a stated time was urged by the state authorities, and in order to save time the contractor was permitted by those in charge of the construction to drive the piles through water with his floating equipment before the fill was made. When later the fill was made, its shifting and settlement caused considerable lateral displacement of the arcade column footing piles and those of the north main bridge pier. These displacements necessitated some troublesome repair work during construction, but the bridge was completed acceptably.

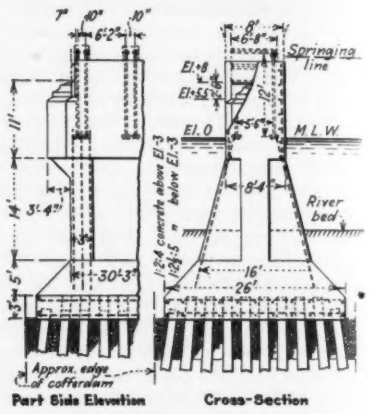


Fig. 2—Buttressed diaphragm-type piers for cantilever spans of Hanover St. bridge, Baltimore, Md., completed in 1917.

Condition before repairs

A careful detail survey of the damages made by the consulting engineers brought out the following general facts: In 1920 repairs had been made at a number of places in the arcade approach of damages caused by continued settlement and movement of the fill. Three columns that had broken away had been replaced, one by reconstruction, another

by a steel column and another by timber posts. Additional damages to the arcade structure disclosed by the survey are summarized in the accompanying column plan, Fig. 3. These are given in some detail, since according to the report of the survey they are attributable to lateral displacement and settlement of the fill. As supporting this conclusion the facts are pointed out that the across-bridge ties between footings show overstress and in one instance have broken, and that the outside columns generally are more damaged than the interior columns. A representative exterior damaged column is illustrated by Fig. 4.

In the retaining-wall section of the approach the walls showed cracks but no settlement. The fill had settled 5 or 6 in., developing a sharp break in the roadway grade where the fill joined the arcade section. One of the cracks at an expansion joint in the wall is illustrated by Fig. 5.

Generally the only damage to the bridge piers had been erosion by ice at the water line, varying from a small amount to cavities 1 ft. or more in depth. The worst damage from erosion was at the bascule piers. Fig. 6 shows the condition at one pier. None of the piers showed settlement.

Damage to the superstructure was found to be in substance as follows: The incased cantilevers and in general all parts under the roadway and sidewalk decks were as a whole in very good condition. The roadway paving showed humps, depressions and cracks and was generally in bad condition, indicating possible injuries in the roadway deck. Chief damage had occurred at the expansion joints, Fig. 7. The report on these joints and the resulting damages to the concrete was (somewhat condensed) as follows:

Expansion Joints—The roadway plates and channels protecting the expansion joints in the roadway are loose and badly worn. There is ample space for contraction and expansion due to temperature in all cantilever ribs, except at the crowns of the spans between piers 1 and 2, and 3 and 4 (the two north spans), where the space is very small and where in several places the ends of the cantilever ribs appear to be in contact. The space between ribs at the crowns of the arches varies in different spans; and since there are no construction records available, it is impossible to state whether there has been a slight movement of the cantilever units due to slight unequal settlements in the pier foundations. The concrete on the ribs is cracking at the joint between piers 1 and 2, and 3 and 4.

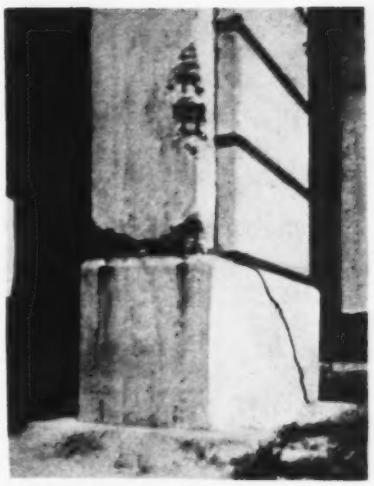


Fig. 4—Exterior column (K1, Fig. 3) of arcade approach, showing type of minor damage. Some columns had been virtually destroyed, and footings for others required reconstruction.

The expansion joints at the crowns of the arches, although adequate for the maximum movement, in so far as

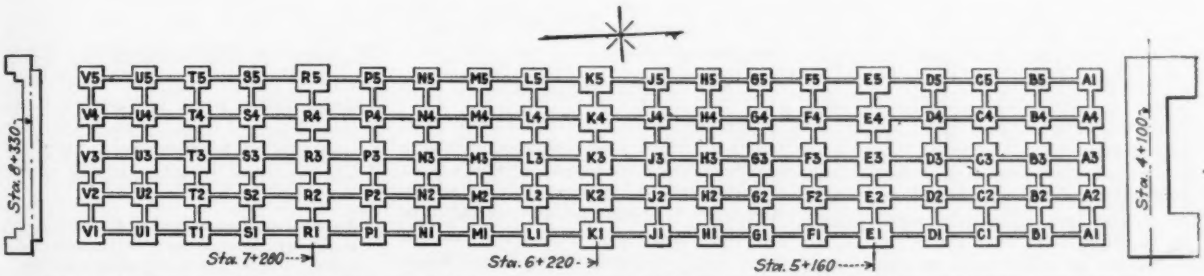


FIG. 3—COLUMN PLAN FOR ARCADE APPROACH, AND ITEMIZED DAMAGE SUSTAINED FROM FOUNDATION MOVEMENTS

V-5—This column or base has failed, and the base has been replaced with grillage incased in concrete. New concrete column is also in place.

U-5—This base is stable, but a bad opening or crack occurs between the column and pedestal base.

T-5—This base appears to have moved S.W. There is one bad crack in column of base and an open joint and poor bearing between column and base.

R-5—The base of the column appears to have moved S.W. All bars in the corners of column are exposed and have rusted. The column is cracked on the west face in three places. There are three cracks in the arches.

P-5—Base appears to have moved S.W. There is one crack on all four faces at top of column.

N-5—The base of this column appears to have moved, and several cracks in the column seem due to bending stress. Two cracks occur at the springline of the arch.

M-5—There is one large crack on all faces of the column at the springline, which may be due to movement of the base.

L-5—The base of this column may have moved S.W. One large crack occurs on face of column at springline of arch.

K-5—One corner of column is cracked away and steel is exposed at base. One large crack occurs in arch at springline. Expansion joint does not function well.

E-5—One bad diagonal crack in west face of column for half of height. One side of base has cracked badly. There are cracks in arches, and facia beam at expansion joint does not expand properly.

Ties—The tie between column U1 and V1 is cracked. The tie between N1 and P1 is gone. A new concrete tie has been built from N1 to P1. Ties from V5 to U5 and V5 to pier 1 are gone. A new tie has been built from N2 to P1.

R1—Reinforcing steel in corners of column has broken out because it was placed too near the surface of the concrete.

V1—Pedestal base is rebuilt and supported on sectional pipe piles. Pipe is in poor condition. Base appears to have moved away from center line of bridge. Open crack occurs between post and base and two cracks occur on side column half way up. There is also a crack at the arch.

P-1—Original column has been replaced by a steel column supported on steel I-beam grillage base. Base is supported on pipe piles.

U-1—Base appears to have moved away from center line of bridge. There are two cracks in the column near springline of arches, and three cracks in each arch between U1 and V1 and U1 and T1.

P-2—The base of this column has settled or moved to the S.W. The corners of column are shattered and the steel is exposed at the base. One crack occurs in column at springline of arch.

R-1—Base appears to have moved east from center line of bridge. All bars in columns are rusting. Two horizontal cracks occur around column at center. Column base was constructed 18 in. south of center line.

N-1—The base of this column has moved S.E., and the column has several cracks at springline of arch. There are three cracks in arches between P1 and N1 and N1 and M1.

L-1—The base of this column has moved S.E. A large crack is noticeable on the west side of the column at springline of arch, and steel is exposed. There is a crack between column and base.

M-1—The base appears to have moved or settled, and a crack appears on all four sides of column at springline.

J-1—The footing of this column appears to be settling. Two cracks in the column below springline extend on all four sides. Two cracks occur in arch between V1 and H1.

K-1—Column base has failed and column has cracks at numerous places. The arches between K1 and V1 and K1 and K2 are supported by timber bents that are loose.

E-3—The base of this column appears to be stable, but the side of the column near the base has cracked and the concrete has crumbled, exposing the steel.

E-1—This column at the expansion joint has numerous cracks at arch and one in the base. All ties appear to have failed, and base has moved S.E.

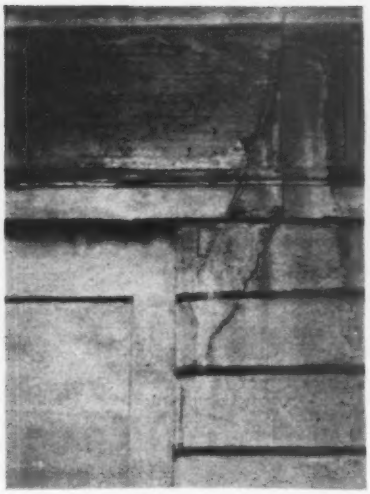


Fig. 5—Example of crack in retaining wall at an expansion joint.

Fig. 6—Example of damage due to ice abrasion on piers for bascule span over navigation channel.

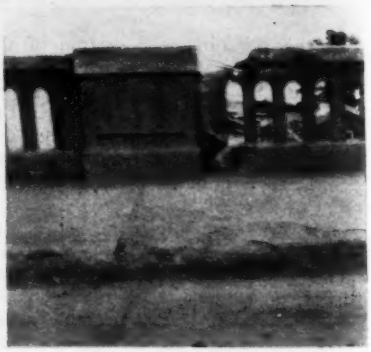


Fig. 7—Typical curb, sidewalk and parapet-wall damage resulting from faulty expansion-joint construction.

the cantilever ribs are concerned, is totally inadequate for the clearance at the curbs, sidewalk slabs and parapet walls. Apparently in some cases, instead of providing an inch or more of clearances for expansion in those portions of the structure, the faces of concrete were poured almost in contact, so that the damage to the curbs, sidewalks and parapet walls hereinafter described is traceable directly to the inadequacy of expansion provision made at the time of construction.

Curbs—The curbs on the bridge were constructed monolithic with the adjacent roadway and sidewalk slabs, and the exposed corner of the curbs was protected with a galvanized-steel curb bar. The bars apparently were placed in position with inadequate space for expansion at the crowns of the arches, and the resulting pressures set up by temperature changes have torn these bars loose adjacent to expansion joints for the full length of the bridge, and in some cases over long stretches on both sides of the roadway. This condition has existed for a number of years, and the disintegration of the exposed concrete surfaces has continued until in some places the curb has practically disappeared.

Sidewalks—The entire sidewalk areas, except possibly 25 per cent, are chipped, spalled and disintegrated, with a vertical displacement at some of the expansion joints.

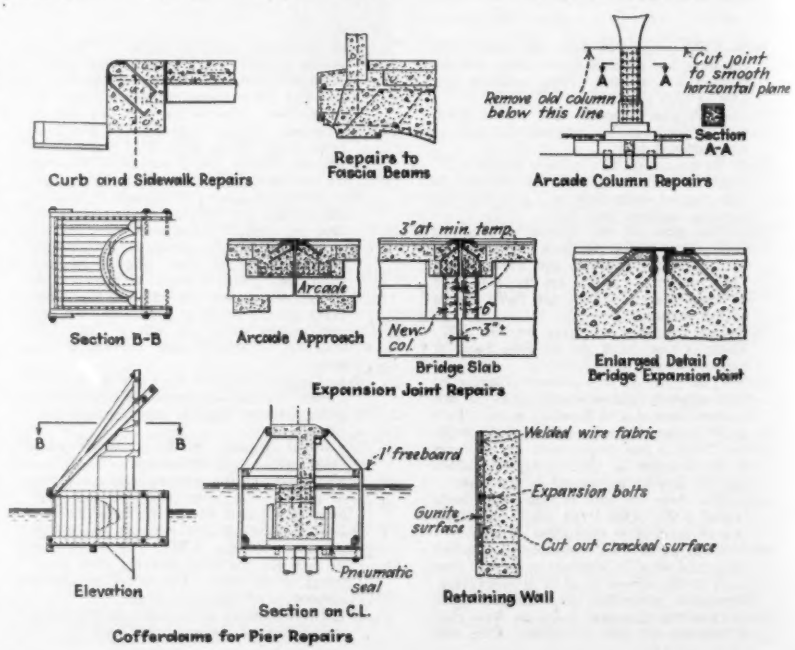
Parapet Walls—The parapet walls immediately adjacent to the expansion joints at the crowns of the arches in practically all cases are badly spalled, chipped and disintegrated as a result of the inadequate expansion space provided during construction. A total of some 200 lin.ft. of parapet posts and parapet walls is in this bad condition. In addition, there is about 125 lin.ft. of parapet wall that has disintegrated and been damaged by traffic accidents. All balusters in the parapet have an unsightly construction joint at the spring line of the small arch at the top of the parapet. The grade along the top of the parapet is very uneven and shows depressions and humps at the expansion joints over the crowns of arches and the center lines of piers. On the north end of the bridge the curb, sidewalk and parapet wall have a long sweeping bend from pier 1 to pier 6 of about 6 in. to the east, which centers at pier 4.

Summarized, the injuries to the concrete are the result, in the retaining walls and arcade approach, of fill movement; in the piers, of ice erosion; and in deck structures of faulty expansion-joint construction.

Repair methods

In general, the repair operations consisted in cutting out damaged concrete and restoring the original structure with new concrete and new reinforcing where required. Essentially the work was patching, although such parts as the curb, new columns, footings and some other parts called for entirely new construction. A new sidewalk slab 2½ in. thick was placed on top of the old slab. Typical plans were prepared for the various kinds of work, as shown by Fig. 8, and general practices were specified. The repair of surface spalling and of

Fig. 8—Typical methods of repairing various damages to concrete parts of Hanover St. bridge, Gunite and high-early-strength-cement concrete being used.



cracks was accomplished by Guniting, a 1 : 3 mix and the usual methods being used. Where the volumes were larger, concrete made of high-early-strength cement was used. The general practice in such operations was to cut out the injured concrete, clean the exposed surfaces and reinforcing steel. Then the old concrete was given a coating of "living stone" in the case of piers, and the new concrete was placed according to the original form of the part.

The three larger groups of repair operations other than Guniting were footing and column repairs in the arcade approach, pier repairs and deck and parapet-wall repairs. While the survey of the consulting engineers had shown in great detail where damage existed or was indicated, it was impossible to uncover everywhere the full extent of damage, and they had, as the repairs were undertaken, this task to perform and the plan and methods to determine or modify. At the same time they again scrutinized every part of the bridge to discover any need of repairs not previously disclosed.

In the arcade approach all footings and across-bridge ties that showed any movement were uncovered. The footings were uncovered sufficiently to disclose the pile tops. Depending on the conditions, the footings were merely patched or entirely reconstructed, including new piles where necessary. Where new piles were required, steel shells were driven down in sections and filled with concrete. Generally these piles were driven outside the old piles, and the footing was extended to embrace them. A high-early-strength concrete was used. Where columns had to be replaced, they were formed and concreted in the usual manner. In such replacements the arcade arches and deck were shored up. Virtually every repair was a special operation.

As the pier caps had been eroded at the water line and under water, the damaged parts had to be laid dry. The damaged parts were inclosed in floating cofferdams of a special design, the damaged concrete was removed, and the cavity filled with high-early-strength concrete or Gunite. Quick-hardening concrete was particularly useful here, as the coffers required continual pumping and could be rather easily overtopped by storm.

In the deck, curb and parapet walls the chief damage as previously stated had resulted from inadequate expansion joints and poor concrete. The repair task was to cut out the shattered concrete and replace it with new, making proper provision for expansion. Some of these devices are shown by the drawings of Fig. 8. As most of the work had to be carried on with the bridge in service, high-early-strength concrete was used where necessary.

In specifying the repair work, quantities and kinds were itemized as closely as possible as a basis for bid prices, but it was understood that these would vary as the damages were opened up and the exact conditions were disclosed. The contractors and engineers therefore worked together virtually item by item in devising the necessary repair work. Both concrete and Gunite specifications follow usual good practice. Generally a 1 : 6 concrete and high-early-strength cement were used. The cleaning of the old concrete and steel and its preparation to insure bond with the new material were given special consideration.

The Hanover St. bridge was constructed by the Maryland state roads commission and later was taken over by the city of Baltimore and became a charge of the bureau of harbors of the department of public works. The work as described was carried out under the supervision of The J. E. Greiner Co., consulting engineers. Bernard L. Crozier is chief engineer of the department of public works of the city of Baltimore. F. M. Kipp is harbor engineer.

Cable Strength as a Measure of Suspension-Bridge Size

RELATIVE bigness in suspension bridges depends upon the units chosen for the measuring. Using the popular conception, length of span, as a measuring stick, the new Golden Gate Bridge, with its 4,200-ft. main span and its 7,694-ft. total length of each cable, takes first place. The George Washington Bridge, with a 3,500-ft. main span and a 5,212-ft. total cable length from anchorage to anchorage, takes second place. Using the diameter of cables as the unit of measurement, the Golden Gate Bridge, with its 36½-in. cables, also exceeds the George Washington Bridge, whose cables are only 36 in. in diameter. If we choose total cable strength as the basis of comparison, however, the George Washington Bridge, with four cables having an aggregate strength of 350,000 tons, is by far the largest. The total strength of the two cables of the Golden Gate Bridge is 193,604 tons. Total strength of cable actually gives the most complete picture in comparative size, for in such terminology is included the requirements not only of length, but width, traffic requirements and additional lanes or decks for future needs.

The accompanying table includes data on the ten suspension bridges with total cable strengths of 25,000 tons and more, and spans from 1,200 ft. up. In the three graphs the bridges are compared

COMPARATIVE DATA ON TEN LARGEST SUSPENSION BRIDGES

Order of Erection	Names of Bridges	Length of Main Span, Ft. (a)		Cable Length Between Anchorages, Ft. (a)		Number and Diameter Cables, In. (a)		Total Strength All Cables, Tons (a)		Strength Per Cable, Tons (a)	
10	Golden Gate	1	4,200	1	7,694	1	2—36.5	2	193,004	1	96,502
8	Geo. Washington	2	3,500	2	5,212	2	4—36	1	350,000	2	87,500
7	Ambassador	3	1,850	3	3,679	5	2—19.25	6	53,500	5	26,750
5	Delaware	4	1,750	5	3,540	3	2—30	3	118,000	3	59,000
4	Bear Mountain	5	1,632	10	2,640	7	2—18	7	47,200	7	23,600
2	Williamsburg	6	1,600	8	2,985	6	4—18.75	5	89,200	6	22,300
1	Brooklyn	7	1,596	4	3,578	10	4—15.5	8	44,800	10	11,200
6	Mid-Hudson	8	1,500	6	3,278	8	2—16.75	9	39,000	8	14,500
3	Manhattan	9	1,470	7	3,224	4	4—20	4	113,200	4	33,300
9	St. Johns	10	1,207	9	2,719	9	2—16.5	10	25,000	9	12,500
	See Graph		Fig. 1.		Fig. 1.		Fig. 2.		Fig. 3		Fig. 3

(a) Numerical relation of size as shown in the column to the right.

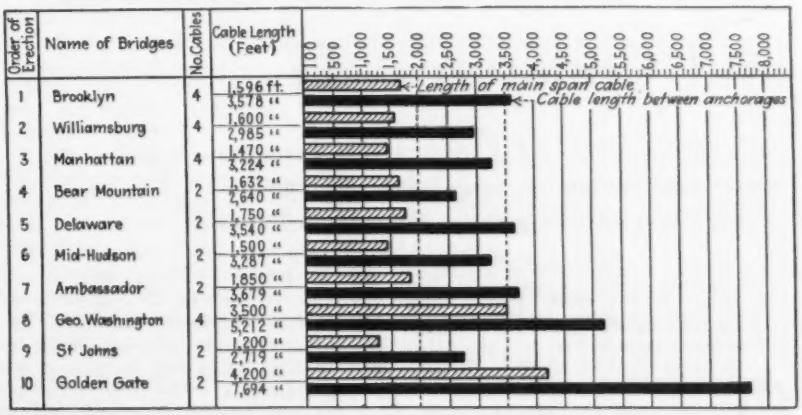


Fig. 1—Ten largest suspension bridges compared on basis of span length and length of one cable.

Abstract of an article appearing in the January, 1933, issue of *Wire Engineering*, published by John A. Roebling's Sons Co.

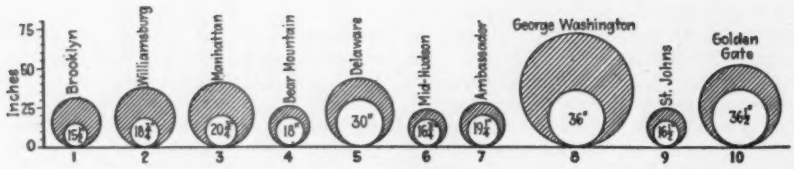


Fig. 2—Comparative cable sizes (white) and total area of all cables (shaded) for ten largest suspension bridges, arranged from left to right in order of age.

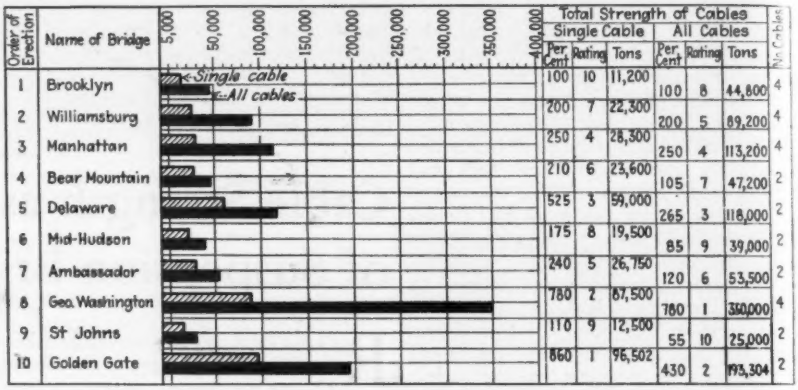


Fig. 3—Cable strength used as basis of comparison for ten largest suspension bridges.

according to: (1) length of span and length of cable; (2) diameter of a single cable and total area of all cables; and (3) total strength of all cables and of a single cable.

The huge size of the George Washington Bridge at New York is readily apparent from the total-cable-strength graph; although if a single cable only is considered, the Golden Gate Bridge exceeds it slightly. In any event, size is best measured in cable strength whether we consider the total strength of all cables in the bridge as a unit or the strength of single cable.

* * *

EDITOR'S NOTE—It is possible also to rate suspension bridges by taking all units of measurements into account at once. Thus, in Roebling's table above the Golden Gate Bridge rates four first places and one second place. The George Washington Bridge rates four seconds and a first, the Delaware River Bridge three third places, a fourth and a fifth, and so on. On this weighted-rating system the ten bridges are in the following order: (1) Golden Gate, (2) George Washington, (3) Delaware, (4) Ambassador, (5) Manhattan, (6) Williamsburg, (7) Bear Mountain, (8) Brooklyn, (9) Mid-Hudson at Poughkeepsie and (10) St. John's at Portland, Ore. Comparing this method of rating with the cable-strength methods, the principal consequence is to place the Ambassador Bridge fourth; in the single-cable-strength rating it is fifth, and in the total-cable-strength rating it is sixth.

The only important structure omitted from the above tabulation is the San Francisco-Oakland Bridge, which is soon to be built. It will include two identical suspension spans. Considering only one span as a "suspension bridge" for purposes of comparison, applicable data and the size rank are: (1) span, 2,310 ft., rank third; (2) length of one cable, about 5,000 ft., rank third; (3) cables, two of 28-in. diameter rank fourth; (4) total cable strength, 68,000 tons, range sixth; (5) single cable strength, 34,000 tons, rank fourth. On the basis of the weighted rating the San Francisco-Oakland Bridge places fourth, slightly below the Delaware River Bridge.

New Facts About Cement and Concrete—II

Abstracts of some A.C.I. papers that give the latest contributions to knowledge on high-frequency vibration, mix economy and column design

THIS Is the concluding part of the report of the American Concrete Institute convention in Chicago, Feb. 21-24. Part I, which included abstracts of the papers presented at the Hoover Dam sessions, was published in last week's issue, p. 110.

OF EQUAL importance with the Hoover Dam research papers presented at the recent convention of the American Concrete Institute were several reports of investigations of placing concrete by means of vibration. From studies at Chicago and Berkeley, Calif., it is concluded that vibration offers a means of increased strength through reduced water content, permits the use of harsher mixtures, produces a more homogeneous mass, thus promoting durability, speeds up placement over hand-tamping and makes possible a saving in cement without sacrifice of strength. A paper on the cost efficiency of concrete developed that this important attribute is influenced most by cost of aggregates and is highest for strong concretes. The fifth report on the concrete column tests was devoted principally to the subject of spiral reinforcement. These various papers are abstracted below.

Vibration studies at Berkeley

Investigations of the relative advantages of vibratory tamping, both internal and external, compared with hand-tamping, that have been under way at the University of California, led to the conclusion that mechanical tamping is in every respect superior. Specimens used were cylinders from 6x12 in. to 2x3 ft. in size, 6-in. walls of various areas, columns up to 9½ ft. high, 4x6-in. plain beams and volume-change bars 3x3x40 in. Mixes varied from 1:2½:3½ to mass concrete proportions (1 bbl. of cement per cubic yard with 6-in. maximum size aggregate). Slumps from ½ to 8 in. were used. The coarse aggregate was gravel, and the fine aggregate was sand with a fineness modulus of 3.0 and a maximum size of ¼ in. The internal vibrators were run at speeds from 4,000 to 7,000 r.p.m., while 3,500 r.p.m. was the motor sped on the external type. Prof. R. E. Davis, who described the investigation in a paper under the joint authorship of himself and Harmer E. Davis, listed the following conclusions, which are presented in abstract:

1. The effect of vibratory tamping is universally to increase the unit weight over that obtained by hand-tamping, but the manner of tamping has no appreciable effect upon the strength.

2. Under conditions encountered in building construction, the maximum form pressures during vibratory tamping may be expected to be about 3 to 4 lb. per sq.in.

3. Harsher mixes may be more successfully compacted by vibratory tamp-

ing than by hand-tamping, suggesting the possibility of reducing the ratio of fine to coarse aggregate, with consequent reduction of volume changes.

4. Durability or weather resistance of concrete may be improved by vibration, as shown by accelerated tests, consisting of alternations of high and low temperatures and wetting and drying.

5. There appears to be a definite advantage in favor of internal vibration of the mass as against vibration applied to the surface of the concrete. This applies particularly to the homogeneity of the concrete and to the efficiency of recombination when segregation has taken place. Also, it appears to apply in the matter of bond between new concrete and that which has hardened, as at construction joints.

6. Perhaps the most striking advantage of vibratory tamping is the effectiveness with which concrete may be placed in intricate forms and in thin, heavily reinforced sections. Also for consistencies normally employed in building construction, compaction is secured much more rapidly through the use of vibratory tamping.

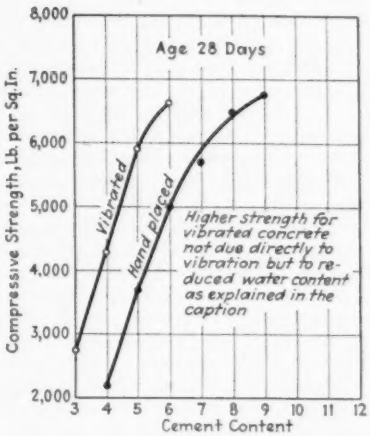
7. For the same ease of placement and the time required for thorough compaction, it is possible with the vibratory tamper to place mixes of much drier consistency than those that can be placed by hand-tamping. It is believed that in general the concrete for walls, beams and columns may be effectively and easily placed through the use of the internal vibratory tamper when the slump is as small as 2 to 3 in., and that in mass concrete construction the concrete may be effectively placed when the slump is as small as 1 in. or less.

8. Through the use of the vibratory tamper there are possibilities of considerable reduction in the cement content of a mix without sacrifice of strength, by maintaining a required water-cement ratio and using the drier consistency that vibration makes possible. Aside from the economic advantage of reduced cost of cement, this reduction in cement content would also seem to possess the added advantage of lower volume changes in the concrete, and possibly also greater resistance to the action of weather.

Further studies are in progress to determine the most satisfactory gradation of aggregate for concrete placed by vibratory tamping and other data relative to means of placement and compaction procedure.

Vibration studies at Chicago

Studies reported by T. C. Powers, of the Portland Cement Association laboratory, Chicago, gave the results of tests made to parallel observations on the practical use of an internal-type vibrator (Viber) on channel-improvement work at Davenport, Iowa. S. A. Healy, the contractor, found that under the same conditions for hand-placed and vibrated concrete it was possible to reduce the water content of the concrete more than 1 gal. per sack of cement or it was possible to produce concrete at a given water-cement ratio with a sack of cement less per cubic yard than with hand-placing. One vibrator and two operators handled as much concrete as six hand-puddlers, though the former worked upon drier and harsher mixes.



Relation between compressive strength and cement content for vibrated and hand-placed concrete. It is to be noted that the higher strength is not due directly to vibration but to reductions in water content made possible by the use of drier consistencies and lower percentages of sand. At a given water-cement ratio the strength of vibrated concrete was the same as workable, hand-placed concrete. These differences, produced in the laboratory, are about double those obtained in the field with present equipment.

The laboratory studies at Chicago demonstrated that vibration does not impart new properties to concrete but makes it possible to utilize the advantages of reduced water and cement content. Mr. Powers' conclusions from the tests are:

1. For normally vibrated concrete, with the apparatus used, the quality of the cement paste expressed by cement-voids ratio or water-cement ratio is the chief factor determining strength.

2. Normally vibrated concrete has the same compressive and flexural strength as workable hand-placed concrete of the same cement-voids ratio.

3. Prolonged vibration reduced the voids but caused little change in strength of dry mixes and decreased the compressive and flexural strength of wet mixes.

4. The 28-day compressive strength of vibrated concrete ranged from 2,500 to 3,000 lb. per sq.in. higher than that of workable hand-placed mixtures of the same cement content, due to reduced water content and lower percentages of sand.

5. Mixes that could be successfully vibrated developed normal strength regardless of the percentage of sand. A deficiency in fines was manifested by complete incorporation of parts of the coarse material, which remained loose at the top of the consolidated mass. The underlying material was always homogeneous.

6. Up to a cement content of about 7½ sacks per cubic yard, the seven-day flexural strength of vibrated concrete was as much as 250 lb. per sq.in. greater than that of hand-placed concrete of the same cement content.

Compared on a basis of maximum unit strength per sack of cement per cubic yard, vibrated concrete reached a maximum 28-day compressive strength of 1,180 lb. per sq.in. per sack as compared with 830 per sq.in. per sack for hand-placing. The greatest strength per sack was attained with 5,900 lb. per sq.in. at 5.0 sacks per cubic yard for vibration and 5,400 lb. per sq.in. at 6.5 sacks per cubic yard for hand-placing.

Vibration in roadbuilding

Comparative use of an ordinary concrete-pavement finishing machine and a vibratory machine carrying three Jackson motor-driven vibrators on the front screed and two on the rear screed were carried out last summer on a section of U. S. Route 50 in Moniteau County, Mo. The results of this experiment were reported by F. V. Reagel, engineer of materials, Missouri state highway department. In the vibrator machine the front screed was made heavier and 18 in. wide instead of 12 in. The slab was of 9–7–9 dimensions, 20 ft. wide, with lip curbing and bar-mat reinforcement. Crushed limestone was used in a 1:2:3.58 mix.

Mr. Reagel reported that vibration was effective in handling concrete of ½-in. slump. In fact, a dry consistency was necessary because the mortar tended to work to the surface under the vibrator machine because of the richness of the mix; a water content of only ¾ gal. per sack did not entirely correct this condition. To determine the effect of varying the mix, the normal mix of 1.44 bbl. of cement per cubic yard was modified by varying the ratio of stone to sand, and other mixes were made with reduced cement content—1.30, 1.20 and 1.13 bbl. per cubic yard; slumps of ½ and 1 in. were used. It was found in these mixes that a water content of 5½ gal. per sack gave a strength equal to that of the regular mix at the same water content. Vibration also appeared to give a more uniform degree of compaction than did screeding and tamping. The strength obtained with reduced cement content indicated that more than 10 per cent of cement could be saved by vibration.

In this experimental work the labor cost was relatively high and practically offset the reduction of cost due to saving in cement, but in regular application a net saving is expected. To assure an even distribution of concrete across the width of the pavement, a mechanical distributor is thought desirable. Some difficulty was encounteerd in building

the lip curbing by hand-work because of the harsh mix.

Concrete quality and economy

In a study of the principal factors of quality of concrete and its economy or cost efficiency, Prof. Inge Lyse, Lehigh University, Bethlehem, Pa., showed the intimate dependence of cost efficiency on the use of a strong concrete. He expressed the view that since the strong concrete in columns is more efficient than spiral reinforcement, spirally reinforced columns "will therefore probably before long be something of the past."

Reviewing the known relation between quality of concrete and its factors of composition, he showed that the strength of concrete (tests by Gonnerman and Woodworth), the permeability (tests by McMillan and Lyse) durability (tests by C. A. Hughes) and fire resistance (tests by Menzel) are straight-line functions of the cement-water ratio.

Studies of economy were based on these data and on various figures for costs of component materials, and were expressed in relative costs per 1,000-lb. compressive strength of the concrete. The principal result of the studies was to bring out the continuous decrease of cost with increase in strength of concrete and the great effect of cost of aggregate upon the cost efficiency of the concrete (*ENR*, July 28, 1932, p. 109). Cost of cement was found to be of secondary influence, mainly because of its relatively small volume in the mix.

Column cost in relation to cost of steel and cost of strength of concrete was separately analyzed, and led to the showing that cost of concrete has in most instances had a more important effect on economy than cost of steel; for example, for 45,000 lb. per sq.in. yield-point stress of the steel and 2,000 lb. per sq.in. strength of the concrete, the steel must be cheaper than four times the cost of the concrete in order to be the more economical material, while the permissible ratio is still lower with stronger concrete. The author therefore concludes that "under ordinary conditions the concrete will be a more economical material than the steel for the production of a given strength. On the basis of economy the spiral reinforcement cannot compete with concrete and longitudinal reinforcement."

While weak concrete is less economical than strong concrete for strength of 3,000 lb. per sq.in. and more, the strength of the concrete has little effect on the economy. As to reinforcement, high yield-point steel proves in general to be the most economical material, because the cost does not usually increase in proportion to the increase in yield-point stress. For equal economy the steel cost per pound may be in proportion to available yield-point strength.

Reinforced-concrete columns

In a fifth report on the column tests that have been carried on at Lehigh University and the University of Illinois during the past few years (*ENR*, May 26, 1932, p. 764) Prof. Inge Lyse gave the results of Series 4 of the co-operative tests conducted at Lehigh. These are concerned mainly with the load that can be sustained for an indefinite time by a reinforced-concrete column. Twenty-eight columns were tested, with longitudinal reinforcement from 4 to 6 per cent, spiral reinforcement from 0 to 2.0 per cent, and loaded to 70 to 100 per cent of ultimate strength. The columns were 8¼ in. in diameter by 60 in. long, made with concrete designed for 4,500 lb. per sq.in. at 56 days; steel was of intermediate grade. As in earlier tests the long-time loading was applied by nests of heavy car springs and adjustable bolts set between the end plates of the columns.

Ultimate strength was determined by rapid loading to failure, and the varying amounts of long-time loading were proportioned from these values. The conclusions from the tests are:

1. The stress-strain curve for rapid loading was substantially equal to the sum of the stress-strain curves for the longitudinal reinforcement and the concrete.

2. The amount of spiral reinforcement does not affect the stress-strain relation for the column at strains less than the yield-point strain of the longitudinal reinforcement.

3. The longitudinal reinforcement will carry its full yield-point stress at strains far beyond the yield-point strain.

4. The column is not weakened by being strained far beyond the yield point of its steel before loading to failure.

5. A reinforced-concrete column (tied or spiral) will probably carry nearly 80 per cent of its ultimate load for an indefinite length of time.

6. A column of no spiral or a small amount of spiral reinforcement will carry 80 per cent of its ultimate load with less deformation and less distress than will a column having a larger amount of spiral reinforcement.

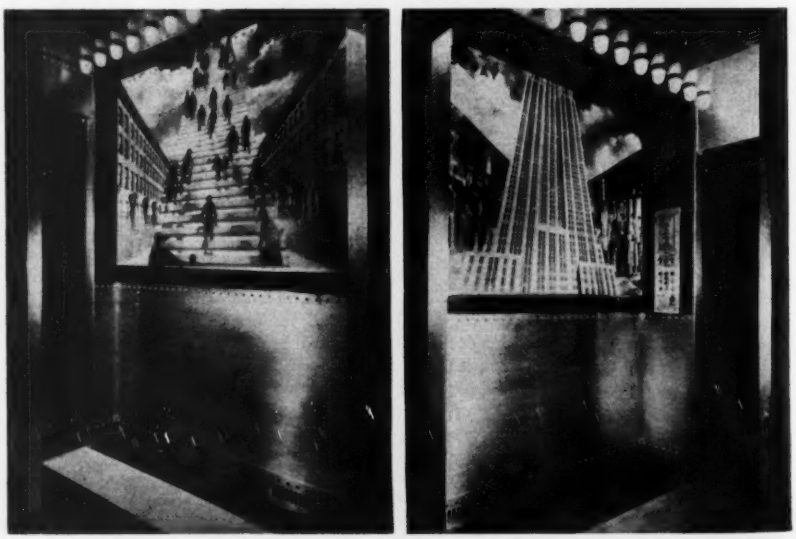
7. The release of the sustained load caused additional distress in the column, and the tied column failed by buckling of the reinforcing bars.

Special Elevator Cars for Skyway Towers at World's Fair

A NEW TYPE of elevator car has been designed by the Otis Elevator Co. for use in the towers of the Skyway transporter bridge at the Chicago Century of Progress. Rivets, instead of being hidden, are given prominence. The aluminum and steel of which the cars are built are used without any attempt at camouflage. Photographic murals used on two sides of the car are emphasized by bright lacquer bands. Besides being decorative these photographs are expected to have a psychological effect, eliminating the confined feeling that passengers experience in many of the present cars.

The installation is also notable in that visitors will be able to view all the inner workings of a modern vertical transportation system from the tops of the two towers. Through shatter-proof glass they may look straight down into the elevator hoistways and watch the movement of the cars. All the automatic-control equipment, the safety devices and the hoisting machines operating the elevators will also be available for inspection.

Photographic murals are used on the walls of the steel and aluminum elevator cars for the Skyway towers at the Chicago Century of Progress exposition



Destructive Earthquake Centers on Long Beach, California

Series of shocks starting on evening of March 10 does $50,000,000 damage, mostly to poorly built structures, and takes over 100 lives—Los Angeles is among 30 cities affected, but damage there is slight

Engineering News-Record Staff Report

EMPHASIZING the adequacy of sound construction as well as its scarcity, the disastrous earthquake that hit Southern California at 6 p.m. Friday, March 10, took a toll of 115 lives and inflicted property damage estimated as high as $50,000,000, half of which was in Long Beach. Rehabilitation was well under way by Sunday, centering in Long Beach where the shock was most severe, while coordinated relief organizations were feeding thousands in parks. Financial developments resulting from the earthquake included the passing of a resolution by the Los Angeles board of county supervisors asking the R.F.C. for a $10,000,000 loan for building earthquake-proof schools and another $10,000,000 for a new court house. The fifty-year-old structure that has been in use was condemned after the first shock. It is estimated that the county would eventually seek $50,000,000 for a reconstruction program. Damage in the city of Los Angeles proper was slight, consisting mainly of broken windows and fallen plaster. Preliminary seismologic data pointed to a center of disturbance offshore, but there was no noticeable tidal wave, and most of the destruction occurred along the Whittier-Inglewood fault line.

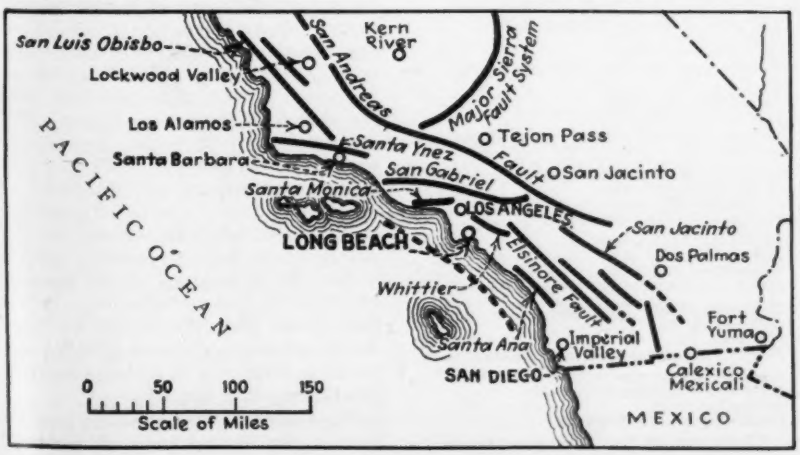
A two-day study of the damage indicates it to be the most extensive suffered since the San Francisco earthquake of 1906. In intensity the tremors probably did not exceed those that damaged Santa Barbara in 1925, but the Long Beach-Los Angeles territory is much more densely settled than that contiguous to Santa Barbara.

Definite estimate of the cost of the damage in the area is impossible until an inspection has been completed, but the original figure of $50,000,000 may be exceeded as structures are examined more closely. Entire blocks of small business buildings, apartments and numerous residences are being condemned and will be razed. In addition, hundreds more will require extensive repairs. In Long Beach the 85 school buildings, valued at about $50,000,000, were estimated to be 75 per cent damaged. In Los Angeles the corresponding loss may exceed $1,000,000. Special investigations into the construction of many of the collapsed school buildings were expected and a coroner's jury of construction experts was planned for the inquest into the earthquake deaths and to hear testimony on matters of sound construction for public buildings.

All major buildings in Long Beach having a steel or reinforced-concrete structural frame are reported by Charles Wailes, building inspector, to be safe, and, on Tuesday, March 14, they were ready for occupancy with the exception of a few where there is hazard from

Map showing area in which structural damage was sustained. Long Beach and Compton suffered greatest losses. (Based on map and reports in *New York Times*.)

Faults in the Los Angeles district, based on a map in John R. Freeman's book on earthquakes. The dotted line offshore marks the location of the San Pedro submarine faults, first stated as the origin of the quake. Later reports mention the possibility of movements along the Whittier-Inglewood faults.



Acme Photo

Upper three rings of a riveted steel water tank near Los Angeles were torn off. Damage presumably caused by surge of water as quake rocked the tank.

Acme Photo

Two-story buildings of this type in Long Beach were wrecked, almost without exception. Similar structures in Compton are also mostly beyond repair.

Acme Photo

Ruins of St. Anthony's Church in Long Beach reveals how unbraced curtain walls acted under shock and sway.

Acme Photo

Midwest Trust and Savings Bank Building in Long Beach, typical of some of the "monumental type" of construction.

loosened plaster. The condition of these large buildings compared to the serious wrecking of many of the smaller, older structures of inferior construction has aroused public opinion to the point of demanding strict building restrictions and earthquake-proof design, particularly for public buildings. In Los Angeles there is no modern downtown building in collapse or even seriously damaged.

Reconstruction activity will depend on the outcome of present plans to secure R.F.C. aid either by individual cities or through a larger coordinated unit. The essential requirement is the need for a revision in the R.F.C. rules for relief loans so that purchase of materials is possible. Much of the reconstruction would be seriously handicapped by a loan restricted exclusively to the payment of wages. At present the work of clearing debris and taking down threatening walls is being carried on by a force of 2,000 men paid $3.20 a day from R.F.C. relief funds available from a loan to the state made prior to the earthquake.

Sound construction stood up

A preliminary survey of the structural damage as illustrated by conditions in Long Beach shows that sound construction, particularly for structures large enough to have received actual engineering design, was adequate to sustain the shocks without serious injury. For example, those buildings five stories or more in height with structural frames, although not necessarily designed for earthquake resistance, are sound, the damage being confined to partitions, plaster and windows. A trip through the fifteen-story Villa Riveria apartments, of structural-steel frame and concrete walls, showed only plaster cracks apparent, although the building was subjected to a severe racking.

Poor construction revealed

The record of such structures as small stores and multiple dwellings is not so reassuring as to the effectiveness of the general type of construction used. Particularly noticeable is the damage sustained by brick fronts and parapets. The number of brick parapets and cornices on one- and two-story buildings that toppled onto sidewalks would be well into the hundreds. Overhanging cornices and heavy belt courses were particularly susceptible. Many of these buildings were old. Without exception they gave evidence of violating the fundamental structural requirement for earthquake resistance that elements of a structure must be securely connected to form a unit. The occasional excellent example of sound brickwork found on larger structures emphasizes the careless work or inferior materials permitted in the small structures. The few small modern buildings of monolithic concrete appear to have excellent records. The parapet and cornice debris on sidewalks in the business districts is so apparent that official action is already being planned to correct this construction defect.

Residential damage was not generally severe and, except for older houses, was mostly confined to fallen chimneys. However, there were numerous instances where the entire house had been loosened on its foundation, and in these cases the fault probably could be ascribed to inadequate support, decay or possibly termite attack.

Utilities not damaged

Service facilities, with the exception of gas, were not seriously interrupted. Electric power has been available continuously since the original shortage. Water supply was restored the second day over practically the entire area, and no important failure of a water-supply system was reported. As a precautionary measure the public is being advised to boil water before using it because of possible contamination, although preliminary tests show no pollution. The gas supply to the area was shut off immediately after the first shock as a precaution against fire. The district is served with natural gas, and it is planned to installed odorizing plants on the supply mains before renewing service.

The official handling of the situation has been efficient and effective. In less than three days the streets of Long Beach are practically clear of fallen material, and the city is in large measure functioning in a normal way.

Newspaper reports from the various cities in the affected areas add some in-

REGION'S EARTHQUAKE HISTORY

The Los Angeles area has been the scene of other earthquakes of "structural damage" intensity, measuring from VIII to X on the Rossi-Forel scale. Some of these, taken from John R. Freeman's book on earthquakes (McGraw-Hill), are listed below.

Location—Los Angeles
Date—July 28, 1769
Intensity—X
Faults Involved—San Pedro submarine faults, San Andreas, San Jacinto and San Gabriel

Location—Southern California
Date—Nov. 27-30, 1852
Intensity—IX to X
Faults Involved—San Juan-Tejon and Tejon-Colorado segments of San Andreas

Location—Los Angeles-San Gabriel
Date—July 10, 1855
Intensity—VIII to X
Faults Involved—San Pedro submarine zone

Location—San Diego
Date—April 8, 1906*
Intensity—IX to X
Faults Involved—San Jacinto and San Andreas

Location—San Jacinto Mts.
Date—April 21, 1918
Intensity—IX
Faults Involved—San Jacinto

Location—Inglewood
Date—June 21, 1920
Intensity—VIII to X
Faults Involved—Inglewood-Newport

Location—Santa Barbara
Date—June 29, 1925
Intensity—X
Faults Involved—Mesa and Santa Ynez

Location—Whittier
Date—July 8, 1929
Intensity—VIII
Faults Involved—Whittier

*Same day as San Francisco earthquake.

Acme Photo

Typical apartment house at Long Beach. Unanchored walls and parapets falling into streets caused principal loss of life.

formation to these first-hand observations. The new $75,000 viaduct over the Pacific Electric Railway tracks between Long Beach and Signal Hill, weakened by repeated shocks, is said to have given way in several places late Saturday afternoon. The new post-office building under construction in Long Beach and scheduled for completion in July suffered heavy plaster and other damage which the contractors estimate will require six months to repair.

In addition to Long Beach, damage was severe in the towns of Huntington Park, Huntington Beach, Compton, Watts and Santa Ana. Shocks were felt in varying degree in all cities and towns south of the Tehachapi Mountains. Other cities reporting damage of varying degree included Santa Monica, Ocean Park, Venice, Manhattan Beach, Hermosa Beach, Redondo Beach, San Pedro, Wilmington, Seal Beach, Inglewood, Florence, Garden Grove and Los Alamitos. Fire wrecked the Huntington Park high school. In Compton "99 per cent of the business property was ruined," causing a loss estimated at $5,000,000. The city hall in Santa Ana was damaged so severely that it was condemned and ordered wrecked. In Los Angeles the 50-year old red sandstone courthouse was condemned as unsafe. The Vernon industrial district of the city was particularly hard hit. The new city hall, with a 470-ft. tower, exhibited numerous plaster cracks. It was ordered closed to visitors, although structurally it was undamaged. The Seal Beach plant of the Los Angeles Gas & Electric Corp. was reported seriously damaged, but service was restored through connection with the Southern Sierras Power Co. It is believed that the majority of the buildings in the affected area were not covered by insurance.

Quake instruments function

According to advices from Washington three stations of the Coast and Geodetic Survey, one at Long Beach and two at Los Angeles, secured good accelerometer readings of the main shock and many of the aftershocks. These readings will be forwarded to Washington for study. The Survey has ten stations in California equipped with the new instruments, the first of which was installed on June 15, 1932, to record strong earth motions, and thus to secure data that would be of use in structural design. These instruments were described in *Engineering News-Record*, Sept. 8, 1932, p. 288, by N. H. Heck, chief of the division of terrestrial magnetism and seismology of the Survey.

Although most reports state the belief that the quake was caused by movements along the San Pedro fault zone off the coast at Long Beach, Dr. Beno Gutenberg, of the California Institute of Technology, is said to have told the Associated Press that the Inglewood faults, starting in the Baldwin Hills north of Inglewood and running southward nearly to San Diego, were responsible.

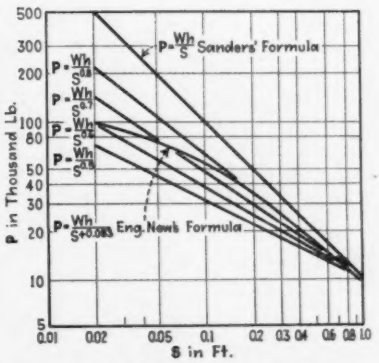
Letters to the Editor

Pile-Impact Formula Fits Test Data

Sir—The writer has been justly taken to task by Mr. Roy M. Harris (*ENR*, Dec. 29, 1932) for his too-comprehensive conclusions regarding his own pile-impact formula (*ENR*, Nov. 3, 1932).

In his specific criticism, however, the latter in turn falls into the same error of making too broad statements. Mr. Harris states that the writer's formula. $P = \frac{Wh}{S^n}$ is not radically different from Sanders' $P = \frac{Wh}{S}$ and the the better-known *Engineering-News* formula $P = \frac{Wh}{S + 0.083}$.

It is true that the Sanders' formula is a special case of the writer's, but because n probably never equals 1, it is not applicable in practice. The *Engineering-News'* formula is distinct in type, as is manifested in the accompanying drawing, where it proves to be a curve when plotted on a log. scale. In passing, it may be noted that the *Engineering-News'* formula is in reasonable accord with the writer's, when n in the latter is 0.7.



Curves of Sanders', *Engineering News'* and Wilcoxen's pile formulas, with an impact (*Wh*) of 10,000 lb.

Regardless of deductive methods of approach, the writer's formula did fit the test data by which it was derived. Neither Sanders' nor the *Engineering-News'* formula would do this.

The writer wishes to thank Mr. Harris for the criticism. Instead of "feels quite sure," he *hopes* that the new formula may prove correct for all types of soils.

L. C. WILCOXEN.

Detroit, Mich.,
Jan. 15, 1933.

Engineering News-Record

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MARCH 16, 1933 Volume 110 Number 11

Opportunity for Progress

QUITE overshadowed by the banking crisis and by the earthquake destruction at Long Beach, the decision of the Supreme Court in favor of Appalachian Coals, marketing agency for bituminous coal, yet adds a weighty item to the week's developments. It affords a ray of hope that sound ways can be found for coping with the evils of industrial overgrowth and blind rivalry, through orderly cooperation within industrial groups. Stabilization, that great desideratum of healthy operation of industry and business, seems to be brought measurably nearer by this decision. That industries can cooperate to some extent under the plain intent of the anti-trust laws has always been known, but because the limit of such action was shadowy there was general fear of any kind of cooperation. The present decision, by helping to define this limit, removes much of this fear. It should permit joint market and cost study, regulation of industry practices, better adjustment of production to prospective demand, and improvement of product quality. Thus, industry is given new opportunity for progress.

Mixed Causes of Failure

THE STORY of progressive failure of concrete at the Hanover Street bridge in Baltimore discloses only few indications that the material itself contributed to the damage that required the extensive repairs recently completed. Except for the pier disintegration at the water line, all failures were obviously the result of fill slippage and restricted expansion. Concrete quality below the standards embodied in present-day technique may have played a part in the extensive eating away of the piers at water level. Ice and water action in this zone of exposure, operating on a concrete placed wet, as was the practice at the time the bridge was constructed, quite likely found a material susceptible of easy attack. The form of pier structure similarly presented a large exposure of area and outjutting parts to abrasion and absorption. In brief, the lesson of the concrete failure at the piers is that of many older concrete structures; too much confidence existed in the permanence of concrete in itself without the contributing support of careful mix design and of placing methods that insured density. Aside from this item, structural factors rather than material account for the bulk of the damage.

The Construction Census

IN THE census report on the construction industry, summarized briefly on another page, the contracting business is for the first time given a balance sheet and inventory. The compilation is valuable in two ways: first, it defines the position of contracting in the roll of the nation's important business groups; second, it constitutes the first basic source of information upon which the contracting business can draw for a valuation of its own elements. In the latter respect the importance of the census can hardly be overestimated. The limited summary possible in our available space represents only a small fraction of the volume of facts given in the hundreds of pages of tabulation in the general report and in the 48 state reports. The possible breakdown of contracting volumes, earnings, labor and material costs and equipment investment by locality, occupation and season is, with the data offered, almost unlimited. Individual analyses have each to be organized and pointed to its specific purpose and cannot profitably be made in general terms. These analyses ought to be made by every branch of the industry. The Census having performed a stupendous task of fact assembly, the construction industry should be prompt in utilizing the results.

New Results in Concrete Placing

FAR-REACHING advances in concrete practice through the aid of high-frequency vibration are foreshadowed by laboratory and field studies carried out during the past year and reported at the American Concrete Institute meeting recently. Vibration makes it possible to place mixtures containing less water and more stone, to counteract the tendency to segregation, and to obtain a dense and homogeneous mass. The chief troubles and weaknesses of concrete construction are thus minimized. The characteristic shortness and lack of body of cement paste, which is responsible for most of the troubles, is neutralized by the effect of vibration, and the constructor is able to place harsh mixes, heavily charged with stone, without running the risk of destructive nesting or clogging and wedging. The material is made to flow, to pack around reinforcement and into form corners, and to consolidate itself by filling all voids in the aggregate with mortar as well as by expelling much of the air churned into the mass during the mixing process. Strength, tightness and durability are enhanced, though complete knowledge of durability obviously waits on long-time experience. Many practical problems remain to be worked out by further development, but enough promise resides in high-frequency vibration to justify its wide introduction into practice.

Evidence on Underground Corrosion

STEEL PLATE of ordinary fabrication was recently removed from a sewer at Newark, N. J., virtually undamaged by corrosion after eighteen years' burial in ground under city streets. Tests of the plate, as given in this issue, indicate virtually no physical or chemical deterioration. With the same conditions continuing, a vastly longer endurance of these tunnel plates is a reasonable assumption. The experience is another step in establishing confidence in the use of steel underground in pipe lines and tunnel lining. It does not justify an easy conclusion that rusting can be simply ignored as a danger to the underground steel of major structures. Only a great amount of further evidence could warrant such an attitude. But the fact remains that the experience with the Newark sewer steel is highly reassuring, and suggests that too great fear of corrosion may be as unwise as too great confidence in its absence.

The Next Step in Recovery

A DESPERATE financial crisis is over, the greatest, perhaps, in the nation's history. Now, with the banks again in operation after complete paralysis for a week, and under the inspiration of forceful national leadership new confidence has arisen from the ashes of three years of persistent deflation. There is evident everywhere a courageous outlook into the future that spells determination to go ahead. The next step is to restore employment.

Re-employment of men in large numbers is necessary, indeed, to make the financial resumption anything more than short-lived relief. Potentially the crisis is still upon us. The past year demonstrated that under the pressure of growing unemployment business is bound to languish despite bank resources and credit, and that declining business means progressive weakening of the financial structure. Restoration of credit facilities after their interruption does not change these conditions. But it establishes a base from which a nation organized in hearty support of a common objective can move forward to new prosperity. The essential thing is to convert the idle worker once more into a wage-earner and thus restart the circulation of trade, money and production.

Until such time as revived industrial demand once more mans the now-vacant factory benches, sole dependence for employment rests on public works. That this is recognized by the new government has already been made clear. Fortunately, a great reservoir of deferred public works is ready to be utilized in providing the initial employment. During the past two years, while the federal government was straining to increase its own works program by a few hundred millions, more than two billion dollars of useful and necessary public works were held up by states and cities because of financial strain and taxpayer alarm. Now, through this huge pent-up volume of work, opportunity is available to meet the day's prime need.

In order to apply this resource to the purpose of recovery, however, a concerted national movement is necessary. No single city or state has the financial courage to go ahead alone; instead, each seeks to curtail its construction farther, to reduce expenses without regard to the inevitable reaction on employment and income. Only by uniting all states and cities under national leadership in a campaign to re-employ the idle through construction of the deferred works will it be possible to achieve the necessary result, and to do so with the speed of action that the times demand.

Clearly, such a movement means reliance on wartime spirit and procedure. But the dramatic events of the past fortnight have brought to general realization that the country's state is more critical even than in time of war. That is why the nation responded so wholeheartedly to the President's leadership. And that, also, is why it will follow enthusiastically in the next step toward prosperity, the attack on unemployment through vigorous prosecution of public works.

Unnecessary Destruction

ONCE AGAIN, as at intervals in the past, comes the news of earthquake destruction, accompanied by a familiar long list of killed and injured. Though the earth movement at Long Beach seems to have been but moderately violent, it did damage in terms of millions throughout a score of communities. Buildings shaken into heaps of wreckage, dislodged beams, cornices and blocks of masonry make up the main part of the story of the earthquake's physical effects. The toll of destruction was due essentially to the insufficient strength of buildings.

Time was when such destruction was unavoidable. It is no longer so. Knowledge of earthquakes and means of resisting them, while still woefully incomplete, has advanced far enough to permit of realizing a high degree of security. The principles of unity and rigidity of construction, with carefully planned flexibility in special cases, as set forth by Prof. Bailey Willis not long ago (*ENR*, Nov. 3, 1932, p. 532), summarize the main essentials of this advance.

Today, therefore, it is no longer necessary that earthquakes should wreck cities and kill large numbers of their inhabitants. Such destruction merely reflects human neglect to apply what is known of earthquake resistance. Building practice is able to give protection, and in the interests of public safety should be required to do so. Especially in known earthquake regions systematic protection is a public duty. Yet, though southern California has an earthquake record as long as its history, even the school buildings were constructed with reckless disregard of the danger, as revealed by their wrecking in last Friday's disaster.

Valuable assistance in the promotion of earthquake safety is at hand in the influence of insurance company and financing authorities. Insurance underwriters have followed the progress of earthquake knowledge closely, and in the case of important buildings in earthquake regions they have demanded that this knowledge be applied. Institutions that lend money for building have in many cases been unwilling to make loans unless earthquake insurance is obtained. Such financial motives will tend progressively to bring a greater measure of building safety, not alone through better design of new buildings, but also through protective strengthening of existing buildings. But this is only one part, and much the smaller part, of the public safety problem.

Safe building is first of all a public responsibility. Being essential to the public interest, it requires that adequate regulation be imposed by the public itself to assure the safety of the community. Such regulation, moreover, must apply not alone to office buildings and costly commercial structures, but to the much larger number of smaller buildings that usually lack the aid of competent structural engineering. It is this class of building that has contributed most largely to earthquake damage and loss of life in the past, and by present accounts also to the destruction wrought last week.

How soon the inhabitants of earthquake regions obtain protection depends upon their own initiative. Knowledge of proper building is sufficiently developed to give a high degree of public security, but in the face of increase in cost it will not find general application until the public insists upon it. With full recognition of the present resources of construction and consistent action to utilize them, the hazards of earthquake calamity can be largely eliminated.

NEWS OF THE WEEK

Additional Bids on Bridge Over San Francisco Bay

BIDS on sections of the San Francisco-Oakland Bay bridge, in addition to those noted last week, have been opened by the department of public works of California. They were for the superstructure of the west bay crossing and the substructure and substructure of the east bay crossing. Last week's bids (*ENR*, March 9, p. 330) were for the substructure of the west bay crossing. Bids on the San Francisco anchorage have been postponed to March 29 and bids on the Yerba Buena Island crossing have been postponed to March 28.

West bay crossing

Bids on the superstructure of the west bay crossing were subdivided into three sections (a) superstructure except cables and attachment; (b) cables and attachments; and (c) a combination of (a) and (b). The Columbia Steel Company, San Francisco, a subsidiary of the United States Steel Corp., submitted separate bids of (a) $9,566,431 and (b) $4,625,977, and a combined bid (c) of $13,732,471. Other bids were McClintic-Marshall Co., $9,693,157 for the superstructure except cables, and John A. Roebling's Sons Co., $4,812,116 for cables and attachments. The west bay crossing consists of two 2,310-ft. suspended spans with anchorages on the San Francisco shore, in mid-channel and on Yerba Buena Island.

East bay crossing

Several bids were received on the substructure of the east bay crossing, a large cantilever of 1,400-ft. span and a long series of lesser spans on 22 concrete piers. The bids were divided into (a) piers 2 to 5, (b) piers 6 to 22, (c) a combination of (a) and (b).

Bridge Builders, Inc., San Francisco bid (a) $2,697,246, (b) $2,034,450, and (c) $4,495,854. The firm of Connolly, Hanrahan & Pollock, San Francisco, bid (a) $2,984,246, (b) $1,846,405, and (c) $4,805,851.

Bidders on separate sections were as follows: Silas Mason Co., San Francisco, (a) $2,989,157; Nealy-Tibbitts Construction Co., San Francisco, (b) $1,922,040; San Francisco Bridge Co., (b) $1,999,670; Mercer-Fraser Co. and George R. Cook, Eureka, Calif., (b) $2,185,565.

Although the firm of Connolly, Hanrahan & Pollock was low on the individual bid for piers 6 to 22 its bid combined with that of Bridge Builders, Inc., on piers 2 to 5 was not as low as Bridge Builders combined bid.

For the superstructure of the east bay crossing the Columbia Steel Company was low with a bid of $8,798,096. A bid of $8,941,580 was submitted by the McClintic-Marshall Corp.

Bridge Builders, Inc., is a combination of the following firms: W. A. Bechtel Company, Henry J. Kaiser, Warren Bros. Co., Missouri Valley Bridge & Iron Co., Dravo Contracting Co., Raymond Concrete Pile Co., and the Utah Construction Co. Officers are: Henry J. Kaiser, president, M. M. Upson, vice-president, S. D. Bechtel, treasurer and K. K. Bechtel, secretary.

A description of the San Francisco-Oakland Bay Bridge was published in our issue of October 20, 1932, p. 457.

R.F.C. approval required

Following the bid openings on March 28-29 the California Toll Bridge Authority will present the results of the bidding to the Reconstruction Finance Corporation. Approval of R.F.C. engineers and financial experts, on evidence that the structure can be built within the $62,000,000 loan figure will be followed immediately by award of the contracts. The results of the bidding thus far with its substantial saving under the estimate figure that was the basis for the amount of the loan indicates that loan should be approved without delay.

$10,000,000 for Public Works in State of Washington

A bill providing for a $10,000,000 bond issue to be spent on public works as a means of unemployment relief has passed both houses of the legislature of the state of Washington and is before the Governor for his signature. The state supreme court will be asked to pass upon the constitutionality of the bill in order that the money may be made available at the earliest possible moment.

Hydro Plant on Mississippi at St. Louis Denied a Permit

The Federal Power Commission, on March 11, denied the application of Carl G. Stifel for a preliminary permit for a hydro-electric power project on the Mississippi River at Chain of Rocks in the vicinity of St. Louis, Mo.

The denial of this application was based, among other things on an unfavorable report from the Chief of Engineers, U. S. Army, who objected to the proposed development on the ground that it would have an adverse effect on navigation and would aggravate flood conditions in the Mississippi River and in the lower reaches of the Missouri River. The Chief of Engineers also reported that the project would cause silting, thus injuring the navigable channel.

In addition to the report of the Chief of Engineers, the commission had before it reports indicating that the proposed development is not economically feasible.

Protests against the project were submitted by the cities of St. Louis and East St. Louis, contending that the water works and sewer systems of these cities would be damaged by the proposed development.

A.S.T.M. Committees Holds Meetings in New York City

COMMITTEES of the American Society for Testing Materials held another of their series of annual spring group meetings in New York City from March 6 to 10. In spite of the bank moratorium which made travel difficult the meetings were well attended and accomplishments in standardization work were substantial. In addition to the committee meetings, a technical program devoted to a symposium on motor lubricants was presented. Among the committees holding meetings were those on steel, wrought iron, cast iron, concrete and concrete aggregates and tension testing.

Particle size determination

In a meeting on particle size measurements J. C. Pearson (Lehigh Portland Cement Co.) pointed out the inadequacy of sieves and discussed air separating and sedimentation devices suitable for measurements in the sub-sieve range. J. R. Dwyer (Bureau of Standards) presented a study showing how fineness measurements made by deficient cement laboratories may be correlated. H. H. Hatch, construction engineer on the Cobble Mountain Dam, described the tests made with a water elutriator and supplemented by hydrometer measurement in determining particle size of hydraulic fill dam materials.

Tension testing

The tentative methods developed by the section on tension testing of Committee E-1 are considered to be suitable for advancement to standard in their present form. A description of the detailed procedure for determining "yield strength," is included in the methods which also include definitions of various properties determined in connection with tension testing, such as "yield point," "elastic limit," "proportional limit" and "tensile strength." It is hoped that the use of these standardized methods and definitions will eliminate the confusion which sometimes has been caused by incorrect conceptions of the various properties of materials as determined in connection with the tension test.

Impact testing methods

At a meeting of the section on impact testing of Committee E-1 consideration was given to the standardizing of apparatus and testing procedure for impact testing of metals by the simple beam method (Charpy) and the cantilever beam method (Izod). An analysis of the replies received to a questionnaire on impact testing also was considered by the committee. Replies received from 43 concerns out of a total of 68 indicated almost unanimous agreement in urging standardization of test specimens for both the Charpy and Izod methods and the development of methods of impact testing. A demand for

standardization of a round impact specimen and for a method of calibration was also shown.

Committee on steel

The meeting of Committee A-1 on steel was one of the outstanding sessions from the point of accomplishment as well as attendance. Among the most important actions taken were the recommendation of advancement to standard of the tentative specifications for structural rivet steel; a recommendation that a special committee be appointed to study the possibility of combining all rivet specifications into one specification containing all necessary categories of rivet steel; approval of new tentative specifications for alloy-steel castings for structural purposes; and the approval of the inclusion in the book of standards and book of tentative standards of a list of specifications for steel suitable for fusion welding.

Wrought iron

The committee on wrought iron voted to recommend to the steel committee that the fabricated pipe specifications, recently issued be modified to include requirements for wrought-iron pipe. Requirements for micrographic examination will also be included in wrought-iron and wrought-iron products specifications if the committee recommendations are approved at the A.S.T.M. meeting in June. A tentative revision in the specifications for welded wrought-iron pipe was recommended for approval. This consists of limiting the manganese to a maximum of 0.05 per cent.

Subcommittee IV on plates, shapes and sheets presented a very interesting report on wrought-iron plates. James Aston (Carnegie Institute of Technology) proposed complete revision of the plate specifications to bring them into better conformity with modern practice.

Corrosion of iron and steel

It was reported that inspections during the year of the bare (uncoated) steel and iron sheets, both copper-bearing and non-copper-bearing exposed under atmospheric

(*Concluded on p. 362*)

Many Companies Bid on Bridge Over Connecticut at Hartford

Many bids were received by the Connecticut River Bridge Commission for its proposesd new bridge over the Connecticut River at Hartford when bids were opened on March 13. Definite award of the contract must wait on the appropriation of money by the state legislature and the approval of the site now favored by the commission as the act authorizing the commission to proceed with planning for the structure approved a site now abandoned by it as too costly.

Eight bids were submitted for the substructure and two for the superstructure but one of the latter was not opened as it was not accompanied by a bond.

The substructure bids were as follows:

Poirier McLane Corp., New York	$2,364,825
Brader Construction Co., New York	2,469,998
Dravo Contracting Co., Pittsburgh, Pa.	2,588,939
Spencer, White & Prentis, Inc., New York	2,657,454
Marcus Contracting Co., New York	2,713,726
Rodgers & Hagerty, New York	2,785,476
George H. Flynn, New York	3,065,984
Arundel Corp., Baltimore	3,070,451

The John A. Roebling's Sons Co., of Trenton, N. J., bid $2,056,400 on the superstructure. The bid of the McClintic-Marshall Corp. was informal and was not opened.

Robinson & Steinman, New York, is consulting engineer to the commission.

Lectures on Regional Planning

A series of lectures on regional and city planning is to be given at New York University in connection with the University's graduate course in regional city planning. The lectures will begin March 22 and will be held Wednesday of each week until the end of May. They will be given at the main building of the University in Washington Square, New York City, at 4:30 p.m. and will be open to the public. Speakers include George McAneny, Jay Downer, E. P. Goodrich, Clarence Stein, George W. Fuller, Malcolm Pirnie, G. W. Farny, E. M. Bassett, H. Eltinge Breed, and Harold M. Lewis.

Contract Let for Reconstruction of Dam at Corpus Christi

Contract for the reconstruction of the LaFruta dam of the Corpus Christi, Texas, water supply district has been let to the J. L. Simmons Co., Bloomington, Ill., for $407,840. The dam is on the Nueces River. It was seriously damaged late in 1930 through undermining of one abutment of the concrete spillway section and the subsequent washing out of part of the earth fill flanking the spillways. (*ENR.* Nov. 27, 1930, p. 861 and Dec. 18, 1930, p. 974.)

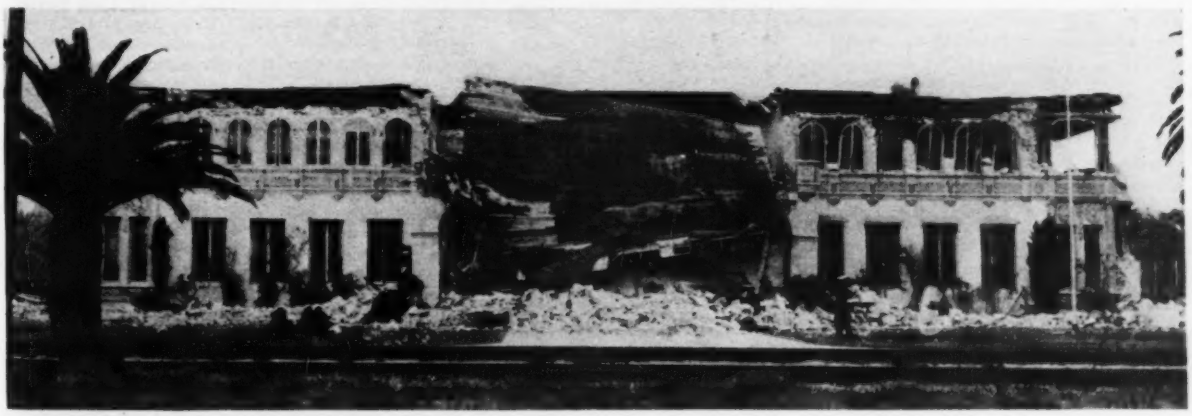
R.F.C. Approves Small Loan for Water Supply at Bethel, Ohio

The Reconstruction Finance Corp., on March 7, approved a loan of $35,000 to the town of Bethel, Ohio, for new wells for its water supply system and for additions to the distributing system. The wells already have been drilled. The work includes the construction of a storage tank of 100,000 gal. capacity and a pumping station.

Loan applications made recently to the R.F.C. include one from Elmhurst, Ill., for $140,000 for a water softening plant of 2,000,000 g.p.d. capacity and a 1,000,000 gal. reservoir. The Kansas Fish & Game Commission has applied for a loan of $250,000 for the construction of two lakes. Hatch, N. M., has applied for $20,000 for an addition to its water supply system and Starkville, Miss., has asked for $102,000 for an extension to the distribution system of the municipal light plant.

Danville, Va., is considering the construction of a hydro-electric power plant as a part of its electric power supply system to permit it to extend its services to adjoining communities. An application for an R.F.C. loan of $2,800,000 is in preparation.

Application for a loan of $1,200,000 for the construction of a union railroad station at Houston, Texas, has been made by the Southern Pacific Company. This loan, presumably, is not applied for under the provisions of the Relief Act of 1932.



CALIFORNIA EARTHQUAKE CAUSES STRUCTURAL DAMAGE OVER WIDESPREAD AREA

Centering on Long Beach but spreading its effect to all surrounding cities including Los Angeles, an earthquake on Friday night, March 10, caused the greatest structural damage sustained in such a catastrophe since the San Francisco quake of 1906. The view shows the city hall at Compton, a town where the damage is estimated to be in the neighborhood of $5,000,000. Bearing-wall structures, such as this city hall, suffered the greatest damage. Parapets and unanchored curtain walls were also particularly vulnerable. Sound construction came through with only minor damage, such as plaster cracks. A detailed news report by a member of the staff of Engineering News-Record appears on p. 353 of this issue.

Detroit Awarded Nominal Damages in Sewer Suit

A VERDICT awarding the city of Detroit nominal damages of six cents was returned by a jury on March 4 in the damage suit instituted in circuit court by the city against Julius Porath & Son, contractor for section 1 of the Southfield sewer, and against bonding companies, the National Surety Co. of New York and Southern Surety Co. of Des Moines.

In the suit the city brought action to recover damages naming the contractors and surety companies and claiming breach of contract. The contract, amounting to $690,000, was let Nov. 23, 1926. Early in 1930, subsequent to completion of the contract and acceptance of the sewer by the city, failures of the sewer wall occurred at Ford Road and 1,800 feet south of Ford Road. The city alleged that investigation by a committee of engineers (*ENR* Aug. 7, 1930, p. 210) disclosed breach of contract and a declaration was filed Aug. 25, 1931. The suit opened Jan. 16, 1933.

Sewer built in tunnel

The section of the sewer covered by the Porath contract was for 8,000 ft. of circular concrete barrel with 10-ft. inside diameter and 16 in. wall specified. Most of it was built in tunnel, part being built entirely through clay and part through quicksand which was under a stratum of clay. Air pressure was used in the sand section of the tunnel.

In the city's declaration, alleged faults included the use of inferior materials; faulty workmanship resulting in low compressive strength; improper placing resulting in thin walls, failure to provide proper keyways at construction joints; failure to use steel liner plates; improper mixing resulting in porous concrete; improper construction methods; excessive use of mortar coating covering up defects in the sewer walls; improper alignment and grade reducing the carrying capacity of the sewer considerably.

Contractor's claims

It was the contention of the contractor that no faulty materials were used, that all were tested and accepted in accordance with the proper standards; that the materials and aggregates were properly mixed, inspected by the city, and were in accordance with the specifications in the contract; that at the time of the work the walls were of proper thickness; that steel liner plates were used where required by soil conditions; that one break in the sewer was caused by a break in an adjoining section of sewer constructed by other contractors and that the surrounding quicksand flowed destroying the stability of the foundation under the sewer; that improper alignment and irregular grade resulted from following locations of points as established by the city engineering department; that failure in the sand section was due to improper design, and that the design used in the clay section was not adequate in quicksand.

The surety companies claimed the work was in accord with the specifications, according to good engineering practice and executed under city inspection; that the work was accepted day by day and that thereby the city waived its rights to any claim for damages. The surety companies further claimed that a change in specifications at the request of the contractors to permit removal of the forms in 24 hours instead of 72 hours as provided in the original agreement, relieved the surety companies of all responsibility.

Testimony on the part of city witnesses was to the effect that 1,840 defective places in the sewer barrel were calked by city workmen; that the calking disclosed thin walls, in some places only 4, 5, and 6 in. thick; that in places the concrete was too porous to hold calking; that the porous concrete allowed infiltration; that construction joints exposed in repair work disclosed the absence of keyways; that a bulkhead covered by plaster was found separating two parts of the sewer barrel within the limits of one of the breaks; also that voids were found above the crown concrete, at one point 13 in. in extent.

Amount of damages

The final amount of damages asked by the city in this case was $335,411, based partly upon alleged cost of repairs and partly on the estimated cost of reconstructing in tunnel the broken sections which were actually rebuilt in open cut.

Testimony of witnesses for the contractor was to the effect that unusual construction difficulties were encountered; that the information about ground conditions as furnished by the city engineer's office was faulty and that due to bad ground conditions nearly a year of extra time was required to complete the contract. The original agreement provided that the contractor should examine the site of the work and satisfy himself as to the ground conditions.

The report by the so called Wrentmore commission of engineers of the investigation into the causes of collapse of the sewer (*ENR* Aug. 7, 1930, p. 210) was not presented in evidence by the city.

Ruling of the judge

Judge Lester S. Moll ruled that there was no evidence of the use of improper materials; no improper mixing of concrete; that although the use of steel liner plates was implied in a note on the original plans which together with the advertisements for bids, the proposal, the contract and specifications, made up the contract agreement covered by law, the use of liner plates was not mandatory on the contractor; that although the city had the responsibility for line and grade of the sewer, errors in line and grade did not excuse the contractor for faulty workmanship; that the question of watertightness was one of intent of the parties as to reasonable leakage and that the contractor was not bound to construct a water tight sewer barrel; that after a final estimate and final payment the city was not estopped from claiming damages; that as no plan was provided by the city for any keyways and the use of a "suitably keyed bond" as specified, was left to the discretion of the contractor, it was a question of fact as to whether the joints were constructed in a suitable manner and in accordance with standard practice at the time of construction; that if material defects were known to the contractor and were concealed with coatings of mortar or plaster willfully or by gross negligence, it was tantamount to bad faith on the part of the contractor and not to be excused even though the city inspectors were constantly on the job.

Engineers to Hold Symposium on Forms of Wood Preservation

A symposium on wood preservation is to be held in the Engineering Societies Building, New York City, during the evening of March 20 under the auspices of the wood industries division of the American Society of Mechanical Engineers. The general subject of wood preservation will be discussed by George M. Hunt of the Forest Products Laboratory. The separate subjects of creosote and creosote mixtures, zinc chlorite, sodium fluorite and the fluorite-phenol mixtures, zinc metarsenite, and fire-resistant treatments are to be discussed by authorities in each field.

Contracts Let for Harbor Work at Monroe Harbor, Mich.

The federal government has let contracts for dredging a channel 15,200 ft. long, 300 ft. wide and 21 ft. deep at Monroe Harbor, Mich., also for the dredging of a turning basin and for the construction of a dike on the east side of the channel using spoil from the channel.

Contract for dredging 2,300,000 cu.yd. from the channel and for placing 16,000 tons of riprap was let to the Construction Materials Corp. of Chicago at a unit price of 14.4c. per yard for dredging and $2.60 per ton for riprap. Contract for dredging 1,500,000 cu.yd. from the upper end of the harbor was awarded to R. C. Hoffman Construction Co. of Cleveland at a unit price of 11c. per cubic yard. The work is to be done under the provisions of the Emergency Relief and Construction Act and is being carried out under the direction of Major R. C. Crawford, district engineer of Detroit.

Washington Notes

By Paul Wooton

Washington Correspondent

A SUPREME COURT decision of importance outside of the industry affected was rendered by that court on March 13 in the case of the government against Appalachian Coals, Inc., the selling agency for a large group of coal producers. The government had sought by injunction to restrain the agency from continuing its operations on the ground that it was violating the Sherman anti-trust act. In reversing the findings of a lower court, Chief Justice Hughes, who wrote the decision, said "a cooperative enterprise, otherwise free from objections, which carries with it no monopolistic menace, is not to be condemned as undue restraint merely because it may affect a change in market conditions; where the change would be in mitigation of recognized evils and would not impair, but rather foster, fair competitive opportunity. . . . The intelligent conduct of commerce through the acquisition of full information of all relevant facts may properly be sought by cooperation of those engaged in trade, although stabilization of trade and reasonable prices may result. . . . If in actual operation it should appear that the plan is used to impair fair competitive opportunities, the decision upon the present record should not preclude the government from seeking remedy."

Engineers and Surveyors of Minnesota Meet in St. Paul

The Minnesota Surveyors and Engineers' Society held its 38th annual convention in St. Paul on Feb. 23-24 with an unusually large attendance despite the fact that this year the Minnesota Federation of Architectural and Engineering Societies did not hold its convention at the same time. For a number of years the two organizations have met at the same time and have coordinated their programs. About 300 attended the meeting this year.

Protection of trunk highways from encroachment by refreshment stands and billboards and the establishment of roadside forests was the subject of a paper by O. L. Kipp, construction engineer, Minnesota highway department. Prof. Walter S. Myers, of the University of Minnesota, discussed currency inflation and city manager government was discussed by C. C. Ludwig, city manager, Albert Lea, Minn.

The sewage disposal problems of the Twin Cities were presented to the meeting by J. A. Childs, chief engineer of the Metropolitan Drainage Commission. Other subjects were bridge surveys by Walter H. Wheeler, consulting engineer, and the classification of cities and towns in accordance with fire protection by Sanford Herberg, engineer for the General Inspection Bureau of Minneapolis.

Officers elected for the ensuing year were as follows: President, John F. O'Meara, Windom, Minn.; vice-president, A. Kircher, Mankato, Minn., and secretary-treasurer, L. P. Zimmerman, St. Paul, Minn.

Although the Minnesota Federation of Architectural and Engineering Societies held no regular meeting the board of directors met on Feb. 24 and elected the following officers: President, William Nelson Carey, chief engineer, Department of Public Works, St. Paul; vice-presidents, H. R. McAdams, Albert Buenger and John Dawson.

Hoover Dam Notes

The placing of dry riprap on the slope of the fill on the Nevada spillway road was 75 per cent complete on March 4. During the week ended on that date the excavation for the apron and cutoff on the toe of the Nevada spillway crest was completed. The Arizona anchorage tunnel for the 150-ton cableway also was completed and concrete was poured for the Nevada anchorage and for a part of the foundation for the hoist house.

* * *

The percolation stops for the lower cofferdam have been completed and the compacted earth fill was finished to El. 674 on the Arizona side and to El. 684 on the Nevada side. Sufficient width for a roadway has been left on the Arizona side.

* * *

All of the lining in tunnel No. 1 has been completed with the exception of 160 ft. of arch. The outlet portal and transition of tunnel No. 1 also is complete.

* * *

The Lidgerwood Manufacturing Co. has erected 90 per cent of the steel for the head tower of the 150-ton cableway. Riveting is 50 per cent complete.

Bids Called on Two Tunnels for Colorado River Aqueduct

The Metropolitan Water District of Southern California, on April 3, will open bids for the construction of the Valverde and the Bernasconi tunnels of the Colorado River aqueduct. The tunnels are in the western part of Riverside County. The Valverde tunnel will be 7.2 miles long and the Bernasconi tunnel 1.1 mile. Originally it was proposed to call for bids on March 20.

Full-Sized Tunnel Endorsed for Colorado River Aqueduct

Construction of the proposed tunnels for the Colorado River aqueduct with a diameter sufficient for the ultimate capacity of the aqueduct has been recommended to the directors of the Metropolitan Water District of Southern California by Frank E. Weymouth, chief engineer of the district. Mr. Weymouth's recommendation was made in response to a request that he determine whether the district could not save a justifiable amount of money by constructing the tunnels to half their ultimate size. Mr. Weymouth's estimate is that the cost of building all the tunnels to full capacity will be $59,197,000 and that the cost to build them to half their ultimate size would be $47,931,000 or a reduction of $11,266,000. He points out further that if the tunnels now are built to half capacity a duplicate set will have to be built ultimately at a total cost of $43,378,000 or $32,112,000 more than the cost of building one tunnel to the full size. Construction of the smaller tunnel could not be justified Mr. Weymouth states, unless construction could be put off 29 years.

Sir Henry Thornton Dies; International Railway Expert

Sir Henry Thornton, until recently president of the 23,000-mile Canadian National Railway system, died in New York City on March 14 following an operation. He was 61 years old.

Henry W. Thornton was born in Logansport, Ind., studied engineering at the University of Pennsylvania and began his active career as a draftsman with the Pennsylvania R.R. in 1894. Subsequently he was made an assistant engineer, engineer maintenance of way and division superintendent. In 1911 he was transferred to the Long Island R.R. as general superintendent.

In April, 1914, only four months before the outbreak of the World War, Mr. Thornton was called to England to become general manager of the Great Eastern Ry. His appointment was very widely opposed in England but despite the unfavorable atmosphere in which he began to work Mr. Thornton won such general recognition that he was appointed to various positions in the British transport service, ultimately becoming inspector general of transportation with the rank of major general.

Mr. Thornton became a naturalized British subject in 1919 and subsequently was knighted for his war service.

In 1922, because of the disorganized condition of the railroads consolidated into the Canadian National system, the Canadian government asked Sir Henry to become president and general manager of the system. He accepted the appointment in October, 1922, and continued in that position until last summer when he resigned. Under his management notable gains were made in the operating efficiency of the system and a remarkable esprit de corps was developed.

WORK BEGUN AT NORTH SIDE OF RIVER CHANNEL AT MADDEN DAM

Work in the Chagres River at Madden Dam has been transferred to the north side of the channel. The accompanying photograph shows the status of the work at the end of February. Work was begun on the south end of the dam last fall with the river diverted to the north side of the channel. The foundations for that section of the dam have been completed and work is now being concentrated on the north end of the structure.

The dam is being built for the government by the W. E. Callahan Construction Co. and Peterson, Shirley & Gunther.

A.S.T.M. Committees Hold Spring Meeting in New York

Continued from p. 359

conditions at Annapolis, Md., for 16 yr. showed very few additional failures. On the other hand all of the 150 sheets of both the No. 22 and 16 gages exposed in sea water since March, 1927, at Key West, Fla., and Portsmouth, N. H., have failed.

The committee on clay pipe took action to recommend the continuation as tentative of the clay sewer pipe specifications.

Concrete

Committee C-9 on concrete and concrete aggregates approved for submission to letter ballot vote of the entire committee the proposed specifications for ready-mixed concrete, and for light weight aggregate as well as methods of test for absorption by aggregates and a proposesd method of field test for the absorption of mixing water by aggregates.

Masonry building units

At the meeting of the committee on hollow masonry building units a change was proposed in the standard specifications for structural clay tile which will eliminate the old designations of "hard, medium and soft" classifications which are considered misleading. The product will be re-classified on the same basis of absorption limits as now used, except that the "hard and medium" grades with absorption limits of from 6 per cent to 16 per cent will be known as 6-16, instead of "hard and medium." The grade now known as "soft" will be known as 16-25. The first and second numbers in these designations represent the minimum and maximum absorption limits, respectively.

Road and paving material

The committee on roads and paving materials approved for ballot action the specifications for portland cement concrete for pavements prepared by a subcommittee under the chairmanship of R. W. Crum, director, Highway Research Board. The specifications for calcium chloride, which cover material for application to the surface of highways as a dust preventive are being revised in order to enlarge the scope of the specifications to cover calcium chloride for a number of other purposes.

The committee on accelerated weathering tests reported progress in its studies of accelerated methods for testing roofing materials and has prepared a suggested testing procedure which will be published in the annual report of the committee as information. The main problem of the standardization of accelerated weathering is the problem of standardizing the carbon arc, which is the principal feature of the test. The nature and intensity of the light radiated by the carbon arc lamp is dependent upon the nature of the carbon electrodes, the arc voltage, amperage and the length of the arc. As a first step toward uniformity in the lamps the committee has prepared a description and study of measurements of the lamp made during the year.

An investigation of testing methods for bituminous emulsions used for water-proofing has been carried on by a subcommittee under the chairmanship of Lester Kirschbraun (The Flintkote Co.). The progress of these studies which it is expected will result in the development of standard test methods, was reported to the committee.

Brief News

PUMPING OF WATER from the 12 recently-completed wells of the Memphis, Tenn., water supply was begun by the new $2,000,000 Sheahan pumping station on Feb. 21.

BIDS ON $1,000,000 OF SEWER BONDS for Louisville, Ky., called for on March 16, have been postponed to March 30 on account of the bank holiday. Opening of bids on section 2C of the Southwestern outfall sewer, also has been postponed to March 30 for the same reason. This work was estimated to cost about $400,000.

EXCAVATION FOR SAN GABRIEL DAM NO. 1, Los Angeles County flood control project on the San Gabriel River, was started Mar. 3 after formal ground-breaking ceremonies at the site. Contract for construction of the dam, amounting to $8,600,527, was awarded Dec. 28, 1932, to the West Slope Construction Company.

AN EXTENSION OF ONE YEAR, or until January of 1934, has been granted to the Seattle Toll Bridge Co. for the time in which it must begin construction of a toll bridge across Lake Washington between Seward Park and Mercer Island under the joint county-city franchise granted in 1931.

A GEAR FOR REPAIR OF A SHOVEL working on the Dotsero cutoff near Eagle, Colo., was shipped recently from Chicago to Denver by air-express. The gear, ordered by telegraph, left Chicago at 4:30 in the afternoon, reached Denver at 3 the following morning and reached Eagle over the D. & R. G. Western R.R. at 7 a.m. This travel was 1,342 miles, of which 1,013 was by air transport and 319 by rail.

DISSOLUTION OF THE SPRINGFIELD CONSERVANCY DISTRICT in Clark County, Ohio, has been approved by the common pleas court on the ground that present economic conditions do not make the proposal practical, also the International Harvester Co., the largest company in the flood area, has indicated that it is content to endure present conditions. The project has been under consideration since 1929 with the Morgan Engineering Co. of Dayton as engineers.

CITIES IN THE STATE OF WASHINGTON are permitted to extend their services beyond city limits under the provisions of the Bone power bill which was passed recently by the legislature and now has been signed by the Governor. Attempts to put a tax of 1.25 per cent on gross receipts of all municipal utility operations within city limits and of 5 per cent on operations outside the city limits through an amendment to the bill were defeated.

A COURSE IN DESIGN FOR WELDED CONSTRUCTION, similar to one offered earlier in the winter, has been announced by the John Huntington Polytechnic Institute, Cleveland, beginning April 3. The course will be conducted in cooperation with the Lincoln Electric Co. Applicants should be college graduates in engineering or have equivalent practical experience. The course will extend for one week with demonstrations and practical work during the day and lectures in the evening.

SOCIETY CALENDAR

AMERICAN SOCIETY OF CIVIL ENGINEERS, annual convention, Chicago, June 27-30.

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting, Chicago, June 26-30.

AMERICAN WATER WORKS ASSOCIATION, annual meeting, Chicago, June 12-16.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, annual meeting, Chicago, June 27-30.

ENGINEERS WEEK, Century of Progress Exposition, Chicago, June 25-30.

ILLINOIS SECTION, American Water Works Association, will hold its meeting at Rockford, Ill., April 19-20.

LITTLE ROCK ENGINEERS CLUB, Little Rock, Ark., at its annual meeting held recently, elected M. Z. Blair, sanitary engineer of the State Board of Health, president, and R. C. Gibson, engineer of the state highway department, vice-president.

EIGHTEENTH ANNUAL summer management course, Pennsylvania State College, is to be held at State College, Pa., June 7 to 14, inclusive. The course will be held under the auspices of the Department of Industrial Engineering and the Engineering Extension Department.

NEW YORK SECTION, American Welding Society, will hold a meeting in the Engineering Societies Building, New York, during the evening on March 23 devoted to the practical design of welded steel structures. H. M. Priest, designing engineer, American Bridge Co., will address the meeting.

INDIANA SECTION, American Water Works Association, has postponed indefinitely its proposed meeting scheduled for March 28 and 29 at Fort Wayne. The action was taken by the executive committee on account of the economic condition under which it was felt few water works men could arrange to attend. C. K. Calvert, Indianapolis, is secretary.

Personal Notes

ARTHUR S. TUTTLE who recently retired as consulting engineer to the Board of Estimates and Apportionment, New York City, has opened an office at 350 Madison Ave., New York City, as a consulting engineer specializing in municipal problems.

J. D. LEVIN, construction engineer, office of the Supervising Architect, has been transferred from the border station at Babb-Piegan, Montana, to Roosville, Montana, to supervise construction of the new border station there.

WALTER F. BARKER and CECIL RIDENOUR, formerly vice-president and superintendent, respectively, of the Sayre Steel Construction Co., have formed the Steel Erectors, Inc., with offices at 50 Church St., New York, to specialize in erection of bridges, viaducts, tanks and industrial buildings.

Obituary

ROBERT B. HOWELL, United States Senator from Nebraska, and formerly state engineer and city engineer of Omaha, died March 11. Mr. Howell was born in Adrian, Mich., Jan. 21, 1864, and graduated from the U. S. Naval Academy in 1885. After studying law for a brief period he went to work for the water company of Omaha. From 1895 to 1896 Mr. Howell served as state engineer of Nebraska and from 1896 to 1897 as city engineer of

Omaha. Subsequently as state senator he secured legislation resulting in public ownership of the water system of Omaha. In 1912 he was appointed water commissioner of Omaha and continued on that board and on its successor, the Metropolitan Utilities District until 1923. Mr. Howell was instrumental in securing the creation of the Metropolitan Utilities District including Omaha and adjacent municipalities. In 1917 he fostered the legislation providing for the establishment of Omaha's municipal ice plant and for the acquisition of the gas plant.

E. M. NICHOLS, for many years active in water purification work in Philadelphia, died at his home there on Jan. 2. Mr. Nichols was one of the oldest members of the American Water Works Association and one of the organizers of the Engineering Club of Philadelphia.

CARLETON J. KING, formerly an engineer of the Long Island State Park Commission, died at Glens Falls, N. Y., on March 7, age 40. Mr. King was a graduate of Cornell University, class of 1915, and had served as an assistant engineer in the public works department of Philadelphia and in the New York State highway department.

LOUIS P. WOLFF, consulting engineer, St. Paul, Minn., died at his home there on March 8, age 65 years. Mr. Wolff was a native of Red Wing, Minn., and a graduate of the college of engineering of the University of Minnesota. After some time in railroad engineering work he became city engineer of Red Wing and subsequently city engineer of Eau Claire, Wis. In 1901 Mr. Wolff purchased the consulting engineering practice of C. F. Loweth and had continued in private practice since that time, specializing in municipal and sanitary engineering work. In 1915 Mr. Wolff was appointed a member of the Minnesota State Board of Health, the first engineer to be appointed to that body. He continued in that position until his retirement on account of ill health in 1930. He also served as a member of the St. Paul Charter Commission from 1917 to 1924.

B. J. T. JEUP, formerly city engineer of Inlianapolis, died Feb. 28 at the age of 68. Born in Cincinnati, he attended the University of Cincinnati and Columbia University and graduated from the latter in civil engineering. His early experience was gained in the New York City Board of Health. Going to Indianapolis as assistant city engineer, he was city engineer under three mayors. In 1916 he became chief engineer of the Indianapolis Water Co., which position he held until 1926, when he became a member of the Board of Sanitary Commissioners. After serving as president of the board for two years he resigned in 1931 on account of ill health. Recently he completed a survey of the municipal government of Indianapolis and advised with the city council and civic organizations on municipal problems.

Engineering Contracts and Capital

POSTPONEMENT of many contract awards because of the current financial situation held the total of engineering construction contracts reported for the past week down to the low total of $8,339,000, as compared with a total of $18,078,000 for the previous week. The average of contracts let during the last four week is $13,255,000. A year ago the weekly average was $18,023,000. Last week the total of public works contracts reported was $5,727,000, and private $2,612,000.

Effects of the bank holiday are expected to be felt in construction circles for some weeks to come. Not only have contract awards been deferred, but in many cases opening of bids has been postponed. Noteworthy examples of the latter case include the Valverde and Bonasconi tunnels on the Colorado River aqueduct, and the San Francisco approach and anchorage and the Yerba Buena crossing of the San Francisco Bay Bridge. Low bids received on projects which have not as yet been awarded include the substructure for the Hartford, Conn., bridge, $2,365,000; superstructure for same, $2,056,400; and the following on the San Francisco Bay Bridge: west bay substructure, $6,957,101; east bay substructure, $4,495,854; west bay superstructure, including cables, $13,732,472; and East Bay superstructure, $8,798,096.

The financial situation was also reflected in the amount of new productive bond issues sold last week. The total reported was less than $2,200,000, of which $1,400,000 represented advances by the Reconstruction Finance Corp. on previous commitments for self-liquidating loans. The R.F.C. agreed to finance one additional project, a $35,000 waterworks development for Bethel, Ohio. These figures bring the total commitments of the R.F.C. to date to $179,652,850, and actual advances to $23,849,000.

Contracts and Capital

CONSTRUCTION

(Thousands of Dollars)

	Weekly Mar., 1932	Average Four Weeks	Week Mar. 16 1933
Federal government	$2,487	$2,666	$2,133
State and municipal	7,643	4,558	3,594
Total public	$10,130	$7,224	$5,727
Total private	7,893	6,031	2,612
Week's total	$18,023	$13,255	$8,339
Cumulative to date:			
1932		$233,464	
1933		192,914	

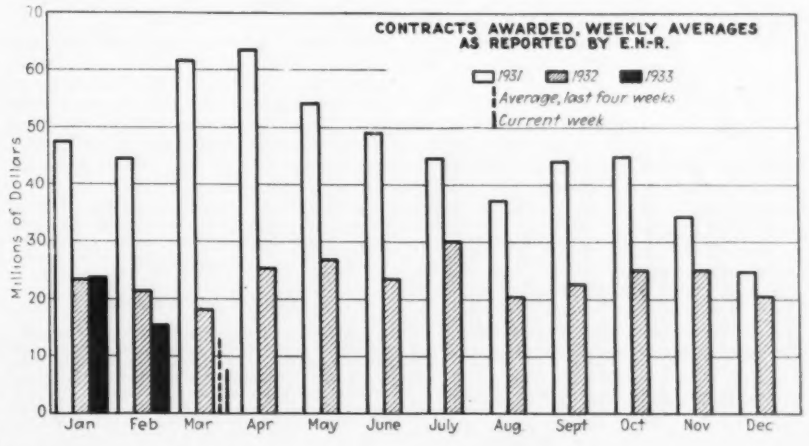
NEW PRODUCTIVE CAPITAL

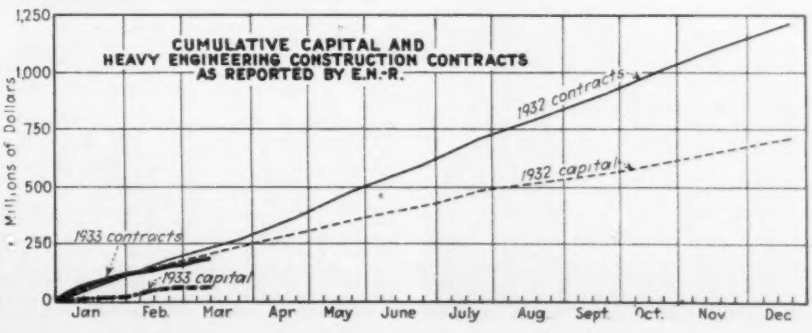
(Thousands of Dollars)

	Weekly Mar., 1932	Average Four Weeks	Week Mar. 11, 1933
R.F.C. loans made	.....	$1,500	$1,400
New capital issues	$17,200	1,600	800
Total	$17,200	$3,100	$2,200
Cumulative to date:			
1932		$297,400	
1933		64,300	
R.F.C. self-liquidating loans:			
Approved current week			$35
Approved to date (including 1932)			179,653
Actual loans made (including 1932)			23,849

ENR Cost and Volume Index

E.N.-R. Cost		E.N.-R. Volume	
March, 1933	158.44	February, 1933	82
February, 1933	159.30	January, 1933	129
March, 1932	157.24	February, 1932	105
1932 (Average)	156.97	1932 (Average)	127
1931 (Average)	181.35	1931 (Average)	220
1930 (Average)	202.35	1930 (Average)	260
1913 Average	100		





Construction Equipment and Materials

New Garbage-Collection Truck Has Roll-Type Cover

Motor truck bodies designed for use in collection of refuse are announced by Fitz Gibbon & Crisp, Inc., of Trenton, N. J. They are characterized by large capacity, low loading height and sanitary features.

The bodies are 10 ft. long and fit a 2½ ton truck and have a capacity of 5 cu.yd. up to the loading line and a total capacity of almost 7 cu.yd. when fully loaded and with the sides closed. A depressed floor allows placing part of the load below the top

Garbage-truck body has low loading height

of the chassis frame. The loading height is 60-in. from the street. The sides are fully enclosed, with a roll type of metal curtain so designed that any or all of the four sections can be opened or closed as desired. The floor is watertight and a tailgate is fitted with a gasket to eliminate drip. A hoist operates the body for dumping.

A number of the new refuse bodies have recently been purchased by the city of Baltimore, and were built at their specifications.

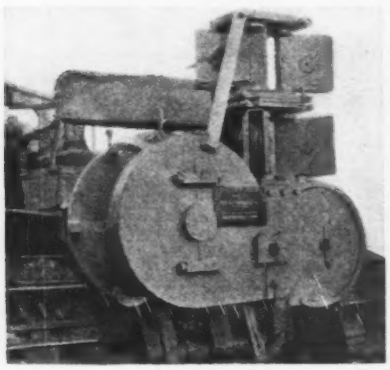
New Cable Power Unit

R. G. Le Tourneau, Inc., Stockton, Calif., have just placed on the market a new logging-type cable power unit, which, beside providing the operator with a high-speed power drum for handling cable-controlled machinery such as a bulldozer, cowdozer or rooter, affords him a heavy drum for tough pulls, pulling stumps, bunching logs, logging short shows, etc. The new unit fits all large tractors.

The two drums can be operated independently, either while the tractor is in motion or standing, and both lines run through fairleads which enable them to pull in any direction regardless of how the tractor is headed. The large drum handles 580 ft. of ¾-in. cable; the small drum 920 ft. of ½-in. cable.

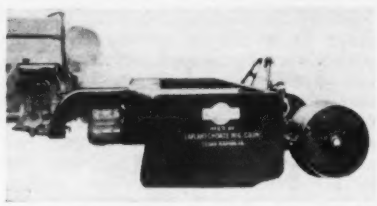
All shafts are heat-treated nickel-steel; gears are case-hardened nickel-steel and run in oil, bearings are high duty Hyatt and Timken. The brake has a patented feature which permits the drum to spin absolutely free when the lever is thrown to release position but automatically grips when the clutch is released.

Logging-type cable power unit by Tourneau.



Bottomless Scraper of New Design

A new bottomless scraper known as the LaPlant-Choate (Knapp) scraper is announced by the LaPlant-Choate Manufacturing Co., Inc., Cedar Rapids, Iowa. The design causes the earth to be rolled along so that only a minimum amount of



Bottomless scraper with hydraulic control

power is required to pull it. The curvature of the back of the bowl lifts and rolls the earth at the same time, enabling large capacity loads to be hauled. Hydraulic power for operating it is obtained by an oil pump placed on the tractor power take-off. A lever that controls the depth of cut is placed within convenient reach of the operator's seat. The cutting depth can be varied from 1 in. to about 12 in.

The bowl is capable of being tilted at either end, aiding the start of a cut on a steep side hill.

New Publications

Plywood. Test data, drawings of construction details, finishing instructions and other helpful facts about Douglas Fir Plywood are presented in a new illustrated booklet for architects and builders just announced by Douglas Fir Plywood Manufacturers, Skinner Building, Seattle, Washington.

Road Machinery. The 1932 Pictorial Catalog is now ready for distribution by the Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill. The equipment illustrated includes graders, tractors, dump wagons, road rollers, snow plows, sweepers and sprinklers, scrapers, etc.

Pulverizers and Crushers. A 48-page booklet, catalog 550, has been published by the Jeffrey Manufacturing Co., Columbus, Ohio, to describe the Jeffrey swing-hammer pulverizers and crushers. The equipment described is classified in two general types, Type A for general purposes and Type B for finer reduction, breakdown and heavier work. The machines operate on the principle of reducing the material by striking it while in suspension. The material is reduced by being fed into the top of the machine and falling in the path of rapidly revolving hammers.

Business Notes

BABCOCK & WILCOX TUBE CO. has appointed Fritz Hoving, West Coast District sales manager with headquarters at 2300 East 55th St., Los Angeles, Calif.

LA PLANT-CHOATE MANUFACTURING CO., Cedar Rapids, Iowa, announce the completion of negotiations with the Knapp Manufacturing Co. of Oakland, Calif., for the joint manufacture and sale of the earth-moving products of each company.

UNION IRON WORKS, of Hoboken, N. J., has become a subsidiary of the Lidgerwood Manufacturing Co. and has moved its activities under a new corporate entity, UNION IRON WORKS, INCORPORATED, to the general offices and plant of Lidgerwood Manufacturing Co. at Elizabeth, N. J.

New Equipment in Brief

Refrigerator Condenser. A vertical-pipe condenser for use in refrigeration is being manufactured by the Ball Ice Machine Co. and the Vilter Manufacturing Co. It comprises a combined gas and liquid header to which are welded vertical pipes. The upper ends of these pipes are sealed. A water header above applies water to the outer surface of the pipe. There is no shell used in the new condenser.

Electric Motor. U. S. Electrical Manufacturing Co., Los Angeles, Calif., announces the U. S. Varidrive motor. The maker states that the new motor offers speeds over a wide range, instantly controllable by the operator while the machine is in motion. Fine variation is accomplished by the micro-speed control which offers speed adjustments as fine as one revolution per minute throughout the entire range for which the unit is built.

Cold-Patch Mixer. The Chain Belt Co., Milwaukee, Wis., has recently introduced an improved model of their cold patch mixer that was introduced in 1932. The new mixer handles either cut-back or emulsified asphalt. It is of the Rex pug-mill design and is equipped with a factory-built-in heater. The mixer has a capacity of 4 to 6 cu.ft. of mixed material, depending upon the type of asphalt and aggregate used.

Diamond Core Drill. The Longyear Prospector is a new diamond core drill, designed and built by the E. J. Longyear Co., Minneapolis, Minn. It is powered by air, gas or electricity and is produced to meet the need for a light, compact drill which may be used with increased economy in drilling holes of moderate depth. Lightness has been secured by the use of magnesium alloys in nearly all stationary parts and by the elimination of all metal unnecessary for strength and safety.

Diamond Core Drill. A new one-man diamond core drill, known as No. 6, has been announced by the Sullivan Machinery Co., 400 North Michigan Ave., Chicago, Ill. The maker states that it meets the need for a light, compact machine of relatively small capacity for shallow underground exploration. The drill weighs 231 lb. complete including the compressed air motor which furnishes the operating power. The same company has introduced a pneumatic rod puller for withdrawing diamond drill rods from down holes when the drill is not equipped with a hoist. The puller consists of a cylinder and piston with a valve and pipe connection to admit compressed air to either side of the piston as desired.